NOV 29 1922

MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

JAMES WATT AND ADAM SMITH

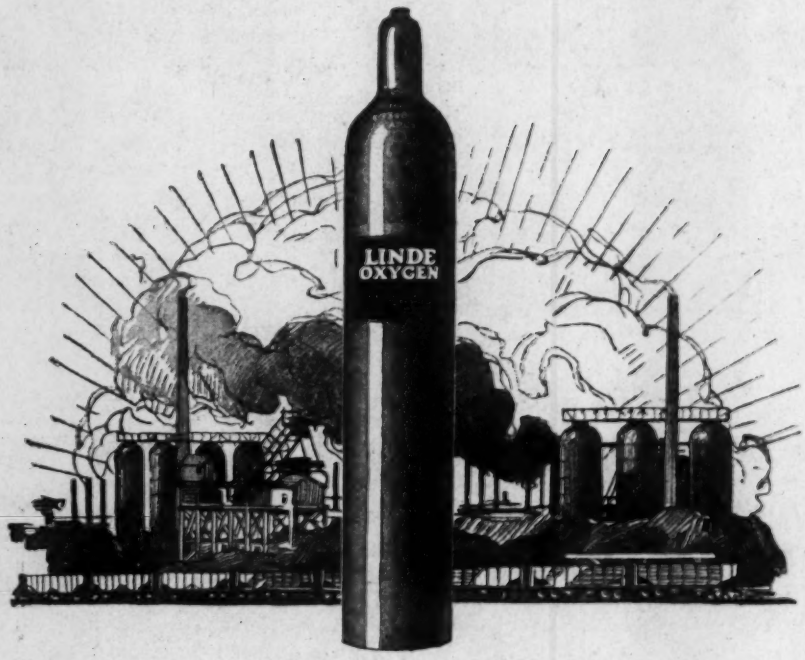
ONE hundred and sixty odd years have passed since Adam Smith and James Watt started their careers in Glasgow. In this interval, the industrial revolution, which was getting under headway in the 1750's, has produced a new world. To us who can look backward it is now clear that this new world is a joint product of engineering and economics. Adam Smith's ideas could not have influenced the reorganization of economic policy as they did without the development of steam power. James Watt's engine could not have run its conquering career without an opportunity for individual initiative. The mathematical instrument maker to the University of Glasgow and its professor of moral philosophy have been more intimate co-workers than either dreamed.

WESLEY C. MITCHELL

(From paper to be delivered Dec. 6, at A.S.M.E. Annual Meeting.)

DECEMBER 1922

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS



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Contributors and Contributions

Size Standardization by Preferred Numbers

Clarence E. Hirshfeld and C. Howard Berry contribute a paper to this issue which tells of preferred-number systems for use in standardization of sizes. Preferred numbers have already been successfully used in Germany and other European countries. Mr. Hirshfeld since 1914 has been chief of the Research Department of the Detroit Edison Company. He holds degrees from the University of California and Cornell University. From 1903 to 1913 he was an instructor and professor at Sibley College. He is the author of a number of books and has been a contributor to the technical press.

Mr. Berry is also with the Detroit Edison Company. He received his M.E. and M.M.E. from Cornell University in 1912 and 1916, and before accepting his present position in 1919 he was for five years an instructor and professor at Cornell.

Steam Distribution in the Locomotive

A new sleeve-valve arrangement for locomotives that can be applied to old engines is discussed in a paper by George H. Hartman. When a young man he became associated with Charles J. Pilliod, of Toledo, who designed the sleeve-valve arrangement discussed in this paper, and although he has left Toledo from time to time he has never severed this association. He has been employed at various times as a designing and consulting engineer for the International Nickel Company, the Dayton Wright Airplane Company, the Willys-Overland Company, the Bacon Motors Corporation and the Hickok Producing Company. At present he is chief engineer and a director of the Cleveland Vending Machine Company.

Machining and Lapping Very Deep Holes

Major John B. Rose of the Ordnance Department, U. S. Army, discusses in detail the shop operations in the production of long and very accurately formed cylindrical holes, such as those in the forgings from which gun-recoil mechanisms are made. Major Rose is a West Point man, class of 1907. Since 1909 he has been in the Ordnance Department and received post-graduate instruction in ordnance engineering. For three years he was in charge of inspection and repair of all ordnance in the fortifications of the Atlantic Coast from Portland to New York City. During the war he was in charge of engineering work relating to the manufacture of our field-artillery material. Since then he has been in charge of the design and manufacture of the field-artillery gun carriages made under the post-war development program.

A New System of Helical Involute Gearing for Use on Metal Planers

Particulars of a system of helical gearing designed by Forrest E. Cardullo for use on metal planers are related by him in a paper in this issue. Mr. Cardullo, who received his degree in mechanical engineering in 1901 from Cornell University spent the first four years after graduation working on the design of heavy gas engines and steam pumping engines. From 1905 to 1914 he was instructor and professor in mechanical engineering at Syracuse University and New Hampshire State University. He then became chief draftsman for the Pierce Arrow Motor Car Company, leaving them to be engineer of tests with the Curtiss Aeroplane and Motor Corporation. Since the war Mr. Cardullo has been chief engineer for the G. A. Gray Co. at Cincinnati.

A New Method for Determining the Effect of Speed upon the Strength of Gear Teeth

The problem of the effect of speed on the strength of gear teeth is presented by Wilfred Lewis, for more than twenty years president of the Tabor Manufacturing Company, of Philadelphia. After his graduation from the Massachusetts Institute of Technology in 1875, Mr. Lewis entered the employ of William Sellers and Company, with whom he remained until assuming his present position. Mr. Lewis has made extensive experiments and investigations along the lines of gearing. He has been the recipient of the Longstreth Medal for some of his inventions and is a frequent contributor to technical journals.

Influence of Design on Cost of Operating Airplanes

Archibald Black, who discusses the cost of operating commercial airplanes, was in charge of the design of the experimental airplane in which the first Liberty airplane engine was installed and was the designer of the L-W-F Model G, the first all-American fighting airplane. Born in Scotland, Mr. Black came to this country at an early age and received his education at Cooper Union, Case Technical Institute, and Columbia University. Before taking up airplane work he was engaged in electrical construction and electrical engineering of power plants for the New York Edison Company, the Detroit Edison Company and the Interborough Rapid Transit Company.

Relieving Industry of Burden

A general plan for lifting the burden from industries suffering from idleness and waste as a result of post-war conditions is presented by Wallace Clark. Mr. Clark is a consulting management engineer of New York City. He was graduated from the University of Cincinnati in 1902. A few years later, after varied experience in this country and the Orient, Mr. Clark became manager of the executive offices of the Remington Typewriter Company, under the direction of H. L. Gantt. Later he became a member of Mr. Gantt's staff.

A.S.M.E. ANNUAL MEETING
New York, December 4-7

Four days of splendid opportunities for professional fellowship at the Engineering Societies Building are to be followed by the National Exposition of Power and Mechanical Engineering at the Grand Central Palace, December 7 to 13.

The January issue of MECHANICAL ENGINEERING will contain a complete account of the technical features of the Meeting, while the A.S.M.E. News will take care of the social events.

MECHANICAL ENGINEERING

Volume 44 December, 1922 No. 12

Size Standardization by Preferred Numbers

By C. F. HIRSHFELD[1] AND C. H. BERRY,[2] DETROIT, MICH.

A careful study of manufactured articles shows that even when sizes are determined by utility or use value, the choice of size is largely arbitrary. It is therefore obvious that if certain numerical values are universally accepted as preferred values, and if they are so spaced and of such extent as to fit in with all requirements met in deciding on sizes to be used, the arbitrary choices may be so made as to yield sizes expressible in terms of these preferred numbers.

Preferred numbers have been successfully used in Germany and some other European countries and this paper is presented as a background for a study of the subject in connection with American conditions and problems. The authors develop preferred-number systems based on the theory of geometrical series and apply them to various industries. Graphs and tables illustrate the points brought out.

SIZE figures in one way or another in all manufactured articles and, in fact, in all articles of commerce. For present purposes the word "size" must be interpreted in its broadest possible sense. It may indicate any one of the following specifications: a purely arbitrary size, such as Model No. 1, Model No. 2, 3, etc., of a given line of manufactured article; a conventional size upon which all manufacturers in a given line have agreed, as sizes of hats or shoes; the weight of a package in which a given material is sold; the weight of some arbitrarily chosen quantity, as 100-lb. rails or 10-oz. duck; an actual or conventional significant dimension, as 1-in. round stock or 1-in. lumber; or any one of the numerous dimensions which may be required in the design, fabrication or marketing of a given article or manufactured product.

Viewed from one aspect, size is second only to the product itself when dealing with the materialistic side of manufacture and commerce. All manufacture and all commerce are carried on in terms of size. In fact, the need for means of expressing size is probably the underlying reason for the heterogeneously assorted system of expression now in use.

Further, size, in the general sense of the word and also in the specific sense, is directly or indirectly made up of two components or factors. One of these is a number and the other a dimension, as in "1-in." bar stock.

Numerous cases will be found in which this composite structure is not evident, but it will always appear if the search is carried far enough. When a given kind of equipment is sold under the size designations, Model No. 1, Model No. 2, etc., the model size itself is determined by its physical size or capacity. Thus Model No. 1 may be 4 ft. high, or may have a capacity of 1 ton in a given time, while Model No. 2 may be 6 ft. high or have a capacity of 2 tons, etc.

In any general study of sizes we must therefore consider two components which are respectively numerals and units of measurement. These units of measurement are matters of custom or use which vary both with the type of measurement and with the systems adopted in different countries.

In considering the so-called "Preferred Numbers" we have no direct interest in these dimensional units. Our concern is entirely with the numerical part of the doublet used for expressing size, except in so far as the relations between dimensions in any one system of measurement may make certain numerals more or less convenient. As an example of the significance of this exception, consider the possible means of expressing a length of 27 ft. in the English system. This might be called 9 yd., 27 ft., or 324 in. In measuring dress goods the yard is the most convenient or at least the conventional unit and thus brings about the necessity for the use of the numeral 9 in expressing the size indicated. In certain other types of measurement, as, for instance, in measuring length of lumber, the foot unit is the most convenient and thus makes necessary the use of the numeral 27. The inconvenience of using the number 324 probably explains the use of feet and yards instead of inches for large measurements.

Sizes used in industry and commerce may be divided into several different categories or classes, as follows:

1 Sizes which are entirely matters of style, such as the lengths of coats, the heights of hats, and other dimensions which change from year to year.

2 Sizes which are determined entirely by personal comfort, such as the sizes of men's collars, the sizes of hats and shoes, etc. Each of these series of sizes has been worked out by experience and it is not unreasonable to assume that at the present time they form satisfactory systems.

3 Sizes which are entirely matters of taste, though not necessarily matters of fashion. Thus the proportions of a Doric column entering into a structure are not determined by strength but by appearance. Proportions or sizes of furniture, objects of art, and many architectural features fall in this class.

4 Sizes which are determined by a combination of appearance and utility. The sizes of drawer pulls, door knobs and the like fall into this class, but for the present they are outside the scope of this paper though they may later fall partly or wholly within it.

5 Sizes which are determined entirely by utility or use value.

Class 1 sizes are by nature arbitrary and changeable and those of classes 2, 3 and 4 are outside the scope of the present paper. Such sizes as are grouped under class 5, whether they refer to buckets and pails, pots and kettles, bolts, wires, or to any of the innumerable machine parts, fall within the scope of what may be called the Theory of Preferred Numbers.

With the preceding paragraphs by way of introduction, something may now be said with respect to this theory, what it is, and what it is for.

The Theory of Preferred Numbers

At the present time there is much that is arbitrary in the choice of size, even when size is determined by utility or use value, and careful study will show that slight variations in the sizes finally decided upon would not make a great difference in the use value of the pieces. For example, have we any proof that pails should be made in 8-, 10-, 12-, and 14-qt. sizes instead of in, say, 9-, 11-, 13- and 15-qt. sizes? Or again, when we calculate the required diameter of a circular section in a piece of machinery to be 2.237 in., are we justified in assuming our calculation so accurate that 2.25 or 2.2 in., or possibly even 2 or 2.5 in., will not prove equally suitable?

Careful study in any drafting room will show that the latitude of choice allowed the designer is such that his decision with respect to final dimensions is arbitrary within certain limits, and quite often within very wide limits.

In view of these facts it is quite obvious that if certain numerical values are universally accepted as preferred values and if they are so spaced and of such extent as to fit in with all requirements met in deciding on sizes to be used, the arbitrary choices may be so made as

[1] Chief, Research Department, The Detroit Edison Company. Mem. Am.Soc.M.E.

[2] Engineer, vice-president's office, The Detroit Edison Company. Mem. Am.Soc.M.E.

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to yield sizes expressible in terms of these preferred numbers. Moreover, if such a thing is possible, very material savings should result from its use, some of the most obvious of which are:

a Mill products which are used in the fabrication of manufactured articles could be made in a minimum number of standard sizes so chosen as to meet the needs of users who have adopted preferred numbers for the sizes of their wares.

b Measuring instruments and production machinery might be simplified and cheapened because it would be necessary to provide

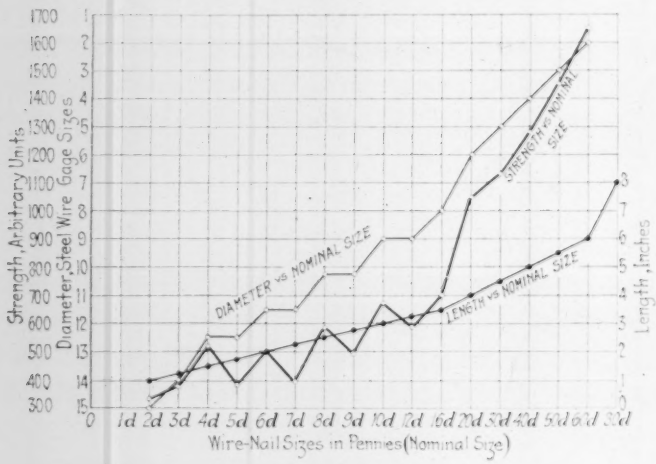

Strength, Arbitrary Units
Diameter, Steel Wire Gage Sizes
Length, Inches
DIAMETER vs NOMINAL SIZE
LENGTH vs NOMINAL SIZE
STRENGTH vs NOMINAL SIZE
1d 2d 3d 4d 5d 6d 7d 8d 9d 10d 12d 16d 20d 30d 40d 50d 60d 80d
Wire-Nail Sizes in Pennies (Nominal Size)

FIG. 1 COMMERCIAL SIZES OF WIRE NAILS

for their use with preferred dimensions only instead of providing for universal adjustment.

c Odd sizes, manufactured through ignorance of real requirements or to meet the supposed, but really illogical, needs of a customer or industry, might be eliminated.

d Life would be made simpler for both the producers and the users, because calculation, manufacture, commerce, catalogs, price lists and human memory would deal only with certain easily memorized and widely used numerals. Certain other advantages will become apparent as the subject is further developed.

One of a practical turn of mind is likely to think that there is much of theory in all this and little of practical worth. Sizes have been developed by a cut-and-try process and with commercial necessity acting as a brake on the overdevelopment of sizes. It might be assumed, therefore, that present-day industry is using the minimum number of sizes consistent with the meeting of human needs and that these sizes are most advantageously chosen. Such arguments are weighty and worthy of serious consideration.

However, systems of preferred numbers have been accepted to a certain extent in Germany, and several other European countries are indicating an intention of following this lead after having made a study of the German systems. It would seem, therefore, that we should not complacently accept our present methods and practices, but instead give serious thought and study to this problem.

The authors of this paper are not urging the adoption of a system or systems of preferred numbers, but they do urge most emphatically a study of the subject in connection with American conditions and problems to the end that decision for or against may be made with full knowledge of all that is involved. Such a study may probably be most conveniently undertaken by considering sizes actually in use in this country and the relation which such sizes bear to a possible series or to several possible series of preferred numbers. Some examples of common cases are given in the paragraphs immediately following.

Common wire nails are sold in sizes expressed in terms of "pennies;" thus we have 2d nails, 3d nails, and so on up to 80d nails. These designations originally indicated the price per hundred, but now, by arbitrary agreement, they represent certain lengths which are expressed in even inches and fractions of inches which have no connection whatever with the number used in expressing the commercial size. The diameters of stock from which the nails are made vary from a small value at the low end of the series to a large value at the upper end. Presumably the nail is intentionally or unintentionally proportioned as a long column, and there is therefore probably some approximation to a definite relation between diameter and length.

The values of length and diameter for wire nails are plotted against the commercial sizes in Fig. 1, from which it can be seen that wire-gage sizes and lengths of wire nails are not as well coördinated as they might be. The nearest convenient commercial size of wire has been combined with the desired length to give a certain size of nail. In fact, half and quarter gage sizes have been used in some cases. The effect of this is indicated by the jagged line showing strength plotted against size. It is obvious that the use of one size of wire for two successive sizes of nails results in most erratic variations in strength. The nails are of course commercially satisfactory, but this does not mean that they are constructed with the minimum use of material or that a more satisfactory line of nails might not be developed. This matter will be considered later after certain other matters have been discussed.

Wire is sold in certain sizes specified as "gages." Copper wire is measured in terms of the American or Brown and Sharpe Gage. The diameters corresponding to successive gage sizes are plotted to semi-logarithmic coördinates in Fig. 2 and it is apparent that this series of sizes was developed according to a definite and consistent plan.

Steel wire is measured in terms of the Washburn and Moen, Roebling, or Steel Wire Gage. The diameters corresponding to

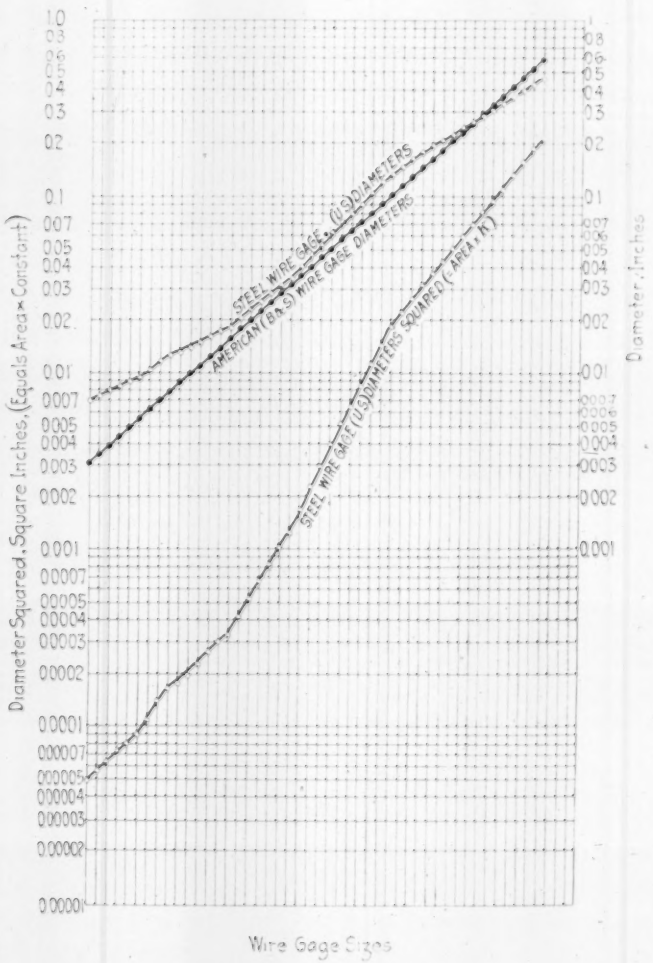

Diameter Squared, Square Inches, (Equals Area × Constant)
Diameter, Inches
STEEL WIRE GAGE (U.S.) DIAMETERS
AMERICAN (B. & S.) WIRE GAGE DIAMETERS
STEEL WIRE GAGE (U.S.) DIAMETERS SQUARED (=AREA K)
Wire Gage Sizes

FIG. 2 SEMI-LOGARITHMIC PLOTTING OF WIRE-GAGE SIZES

successive gage sizes are also plotted in Fig. 2. Evidently there is some underlying plan, but it follows what appear to be imperfect laws. Apparently a certain law of variation is followed until it cannot be followed further. Another is then chosen but later abandoned, and so on. There may be good reasons back of this peculiar variation, but it seems probable that this gage might have

been built up upon a much simpler basis. More will be said about this in later paragraphs.

As another example of sizes in commercial use we may consider frying pans. The diameters of one well-known make of frying pans are plotted against commercial or nominal sizes in Figs. 3 and 4. This matter will also be considered later.

Saucepans and preserving kettles are sold in sizes designated in terms of quarts. Saucepans are made in comparatively small sizes and preserving kettles in comparatively large sizes, but the two overlap so that sizes of equal capacity can be obtained in the larger sizes of saucepans and in the smaller sizes of preserving kettles. The two kinds of utensils are interchangeable in use, so that it is probably not illogical to consider them together. The sizes available in one make are plotted to ordinary coördinates in Fig. 5. The same values are plotted to semi-logarithmic coördinates in Fig. 6.

Liquid measures are available in numerous sizes, all commonly designated in terms of capacity. The sizes obtainable from one well-known maker are plotted to semi-logarithmic coördinates in Fig. 7.

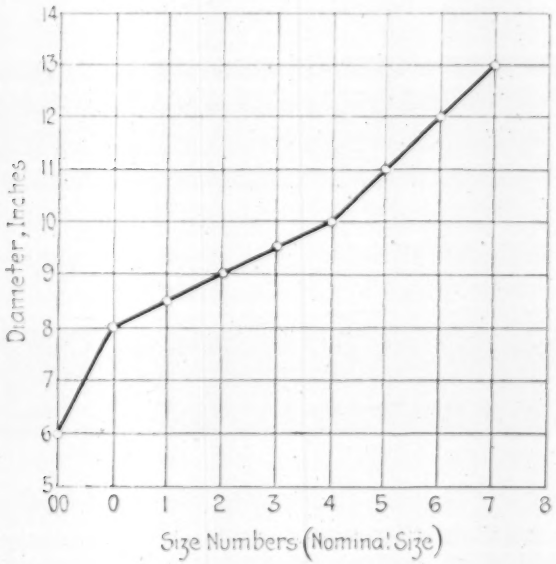


FIG. 3

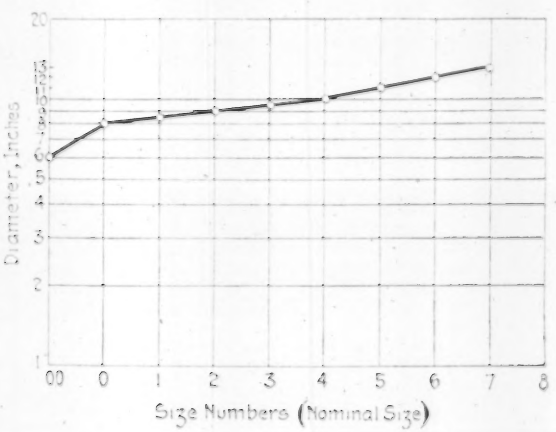


FIG. 4

FIGS. 3 AND 4 DIAMETERS OF FRYING PANS PLOTTED AGAINST COMMERCIAL OR NOMINAL SIZES

Commercial sizes of steel shafting are shown in Fig. 8.

Bolts have been standardized in different ways and for different purposes by various organizations. One very complete standard is that of the Society of Automotive Engineers. The diameter, area of stock, and area at root of thread for S.A.E. Standard bolts are plotted to semi-logarithmic coördinates in Fig. 9. A similar set of graphs for the United States Standard is given in Fig. 10.

Pipes are well standardized in several different weights. They are sold in terms of nominal diameters and the actual diameters practically never equal the nominal diameters. The actual inside diameters and areas of standard full-weight wrought-iron pipes from $^1/_8$ in. to 10 in. nominal diameter are plotted to semi-logarithmic coördinates in Fig. 11.

A brief survey of Figs. 2, 4, 6, 7, 8, 9, 10 and 11, all of which show sizes plotted to semi-logarithmic coördinates, will indicate a surprisingly large number of cases in which successive sizes fall very nearly on one straight line or on two or three straight lines of slightly different slopes. If space permitted many more examples of the same thing could be given.

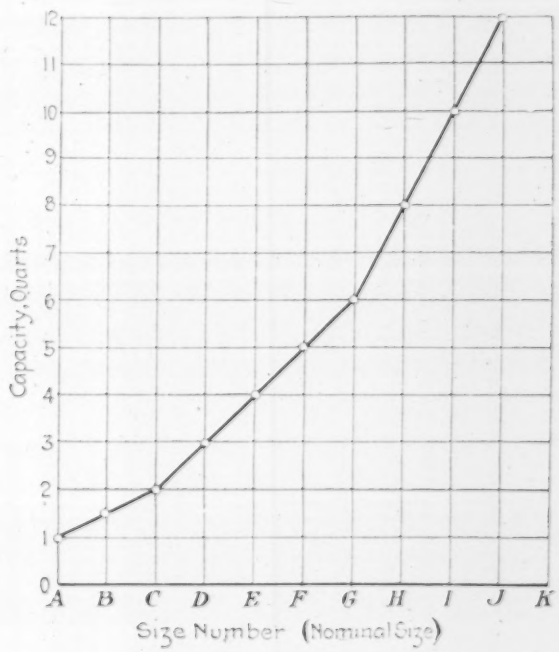


FIG. 5

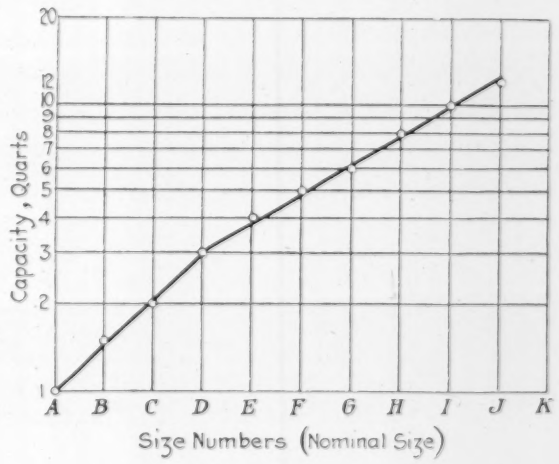


FIG. 6

FIGS. 5 AND 6 CAPACITIES OF SAUCEPANS PLOTTED AGAINST COMMERCIAL OR NOMINAL SIZES

This peculiar tendency naturally suggests some underlying law of size or size variation. If sizes tend to fall on such straight lines, it follows that the mathematical characteristics of such lines must express what we may call the natural law of size variation.

THE APPLICATION OF THE THEORY OF GEOMETRICAL SERIES

On semi-logarithmic paper a straight line which is not parallel to either axis is the plot of a geometrical series. That is, such a line represents a succession of terms each of which bears a constant

ratio to the preceding one. The following succession of terms represents part of a geometric series:

$$a,\ 2a,\ 4a,\ 8a,\ 16a,\ \ldots\ldots\ldots \text{ etc.}$$

Such a series can be written symbolically, as:

$$a,\ ra,\ r^2a,\ r^3a,\ \ldots\ldots\ldots\ldots r^{n-1}a$$

in which—

a = first term of the series or the number on which it is built up
r = ratio of each term to the preceding term, and
n = the number of the term in the series.

German scientists and technicians have investigated this matter

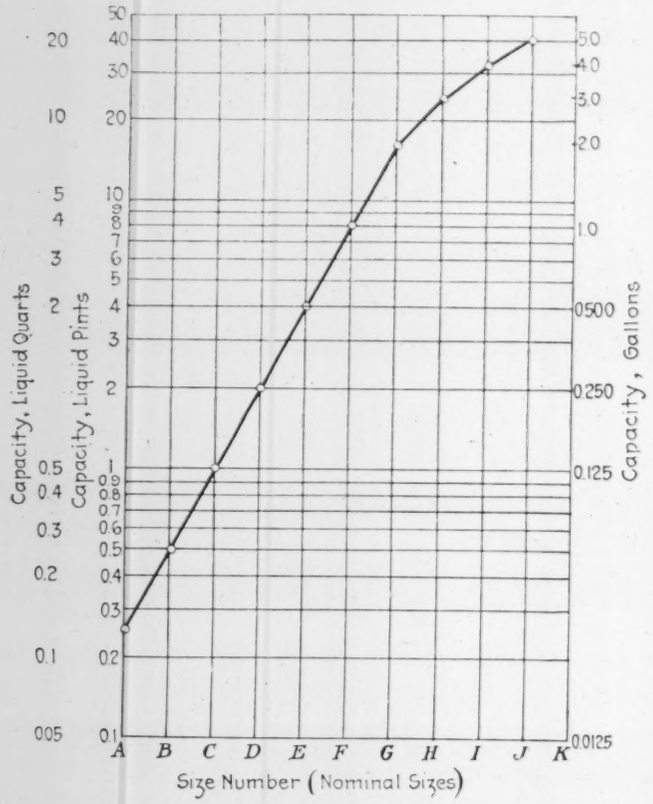


Fig. 7 Capacities of Liquid Measures Plotted against Nominal Sizes

of size variation, including several geometrical series which may be used an expressions of the law of size variation. While they have not yet formally adopted them, they are leaning very markedly toward a system of series with ratios equal to the 5th, 10th, 20th, 40th and 80th roots of 10 and have, in fact, adopted it tentatively. Such series would be simply expressed as follows for the 10th-root series:

$$a,\ \sqrt[10]{10}\,a,\ (\sqrt[10]{10})^2\,a,\ (\sqrt[10]{10})^3\,a,\ \text{etc.}$$

which is equal to—

$$a,\ 1.259a,\ 1.58a,\ 1.99a,\ \text{etc.}$$

For the 20th-root series:

$$a,\ \sqrt[20]{10}\,a,\ (\sqrt[20]{10})^2\,a,\ (\sqrt[20]{10})^3\,a,\ \text{etc.}$$

which is equal to—

$$a,\ 1.122a,\ 1.259a,\ 1.41a,\ \text{etc.}$$

The whole idea can be illustrated most clearly by dealing with the series which has a ratio equal to $\sqrt[100]{10}$, i.e., $10^{1/100}$. Such a series built upon the number 1, that is, with a equal to 1, is drawn to semi-logarithmic coördinates in Fig. 12.

Assume that it is desired to make a given article in eleven sizes progressing as in this series. The size designations are indicated as A, B, C, D, etc., in Fig. 12. The dimensional sizes are given by the values of the ordinates above the size designations. If a smaller number of models equally distributed over the same range of dimensional sizes is required, we might use sizes A, C, E, G, I, and K. But such a choice would be exactly equivalent to using a series such as that shown at the left in Fig. 13, which is a series with the ratio $\sqrt[50]{10}$. Or if we desired only three sizes, say, A, F, and K, this would be equivalent to using the $\sqrt[20]{10}$, or a series such as that shown to the right of Fig. 13.

Bearing these ideas in mind, inspection of Fig. 14 will show that a series with ratio $\sqrt[10]{10}$ makes available only two of the sizes here under consideration, namely, the first and the last. A series with ratio $\sqrt[20]{10}$ gives three sizes, the same two extremes and one intermediate corresponding to F of the original arrangement. A series with ratio $\sqrt[30]{10}$ yields four sizes, the two intermediates not corresponding to previous sizes because 30 is not evenly divisible into 100. A proportionate number of sizes is obtainable with the series with ratios equal to $\sqrt[40]{10}$, $\sqrt[50]{10}$, $\sqrt[70]{10}$, $\sqrt[80]{10}$, and $\sqrt[90]{10}$. The series with ratio equal to $\sqrt[50]{10}$ yields six of the original sizes as previously indicated.

Going back now to the original series with ratio equal to $\sqrt[100]{10}$, shown in Fig. 12, let us assume that the 11 sizes designated by letters A to K, inclusive, are not sufficient, that is, that finer subdivisions are required. These can be obtained by inserting sizes midway between A and B, B and C, C and D, etc., as shown in Fig. 15. We should then get sizes which might be designated as A, $A^1/_2$, B, $B^1/_2$, C, $C^1/_2$, etc., and the dimensions of each size would be related to the dimension of the preceding size by the same ratio, but this ratio would not be the same as that in the case first considered.

The last statement is likely to be a bit puzzling to those who do not handle such series frequently, but it is easily explained. The line as drawn yields a value of 10 as ordinate for 100 of the smallest divisions on the horizontal axis. But 10 is the 100th power of $\sqrt[100]{10}$. The ordinate of the first small division counting from the left on the horizontal axis is therefore equal to the ordinate at A multiplied by $\sqrt[100]{10}$; the ordinate of the second small horizontal division is the ordinate at A multiplied by $\sqrt[100]{10} \times \sqrt[100]{10}$, or $(\sqrt[100]{10})^2$; the ordinate at B is equal to the ordinate at A multiplied by $(\sqrt[100]{10})^{10}$; the ordinate at C is equal to the ordinate at A multi-

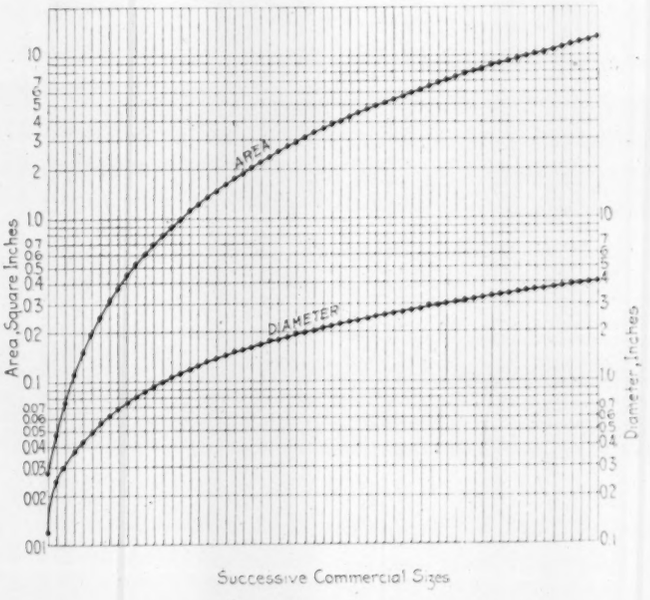


Fig. 8 Diameters and Areas of Steel Shafting Plotted against Successive Commercial Sizes

plied by $(\sqrt[100]{10})^{20}$; and so on. It is therefore obvious that—

Ordinate at B = Ordinate at $A \times (\sqrt[100]{10})^{10}$

Ordinate at C = Ordinate at $B \times (\sqrt[100]{10})^{10}$, etc.

but—

Ordinate at $A^1/_2$ = Ordinate at $A \times (\sqrt[100]{10})^5$, and

Ordinate at B = Ordinate at $A^1/_2 \times (\sqrt[100]{10})^5$.

That is, the ratio between successive sizes of the A, B, C, D, etc., series is $(\sqrt[100]{10})^{10} = \sqrt[10]{10}$, and the ratio between successive sizes of the $A^1/_2$, A, B, $B^1/_2$, etc., series is $(\sqrt[100]{10})^5 = \sqrt[20]{10}$. If

desired, the subdivision can be carried to any extent, but no matter how far it is carried the same characteristic relations will hold true.

If the requirements to be met are such that comparatively small variations of size are required in the smaller sizes and larger variations in the larger sizes, we might choose an arrangement such as that shown in Fig. 16. This appears to be a very minor variation of what has preceded, but in fact it is quite a major variation. The series of sizes resulting from such uneven subdivision no longer has the same characteristics as were described in connection with the sizes *A*, *B*, *C*, *D*, etc. The ratio between successive sizes changes at *E*, *H*, *I*, and *J*. This is shown clearly by plotting dimensions from Fig. 16 with nominal sizes evenly spaced as in Fig. 17. The ratios are indicated on each part of the broken line of this figure.

From what has been done in developing the graph in Fig. 16, it is apparent that its shape will vary with the way in which one chooses to distribute nominal sizes among the possible evenly distributed sizes. If the nominal sizes be closely spaced with reference to possible sizes with any assumed even increments, the resultant line will be less steep than if the nominal sizes are more widely spaced among the possible sizes.

Comparison of Figs. 12 to 17, inclusive, with Figs. 2, 4, and 6 to 11, inclusive, will show sufficient resemblance between the two groups to lead one to suspect that possibly the geometrical series is an expression of the law which underlies variation of size in articles whose size is determined by use value. One may object to such a conclusion by pointing out that in many cases in which actual sizes are plotted they do not fall exactly on the straight lines which have been drawn, and, further, that the use of a logarithmic scale distorts the significance of vertical departure from the lines so that it is possible that a small departure on the plot may mean a large discrepancy in actual size.

Present System Similar to Preferred Numbers

These criticisms are valid but they do not vitiate the suggested conclusion. Rather peculiarly, this is true because we are already more or less unconsciously using a set of preferred numbers. We use certain fractions of inches for dimensions smaller than one inch

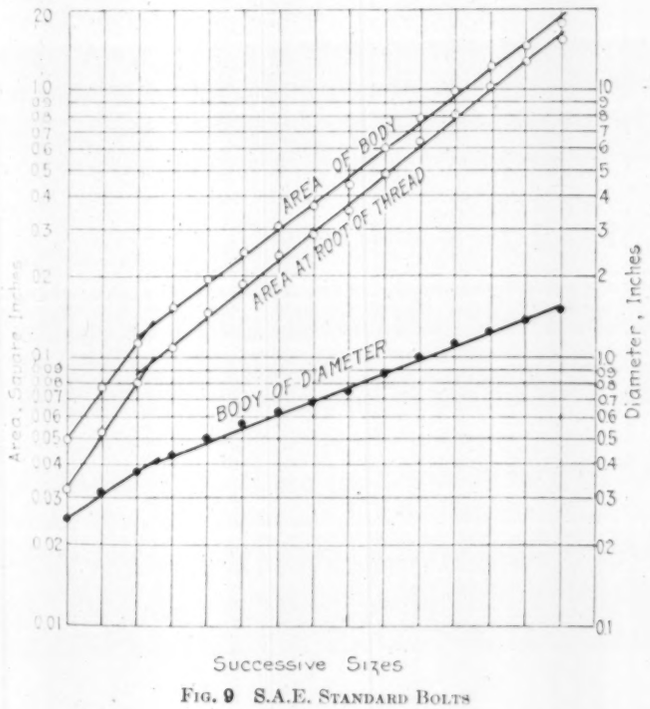


FIG. 9 S.A.E. STANDARD BOLTS

in preference to all other possible fractions. Thus our first choice is $^1/_2$ in.; the next, $^1/_4$ and $^3/_4$ in.; the next $^1/_8$, $^3/_8$, $^5/_8$, and so on. For dimensions larger than one inch we do the same sort of thing but in two different ways. Our choice with respect to fractions of one inch is the same as before, namely, a system based on eight with preference given to $^4/_8$; $^2/_8$, $^4/_8$, and $^6/_8$; $^1/_8$, $^2/_8$, $^3/_8$, $^4/_8$, $^5/_8$, $^6/_8$, and $^7/_8$; etc., in the order indicated by groups. But for fractions of one foot we use a system based on twelve and, whether we express ourselves in inches or in fractions of a foot, we give preference to $^6/_{12}$; $^3/_{12}$, $^6/_{12}$, $^9/_{12}$; $^2/_{12}$, $^4/_{12}$, $^6/_{12}$, $^8/_{12}$, $^{10}/_{12}$; etc., in the order indicated by groups.

Therefore, in actually setting the dimensions which shall characterize different sizes of manufactured products, we generally choose on the basis of these preferred numbers, using that one which happens to fall nearest to our desire in each case.

Consider, for example, the dimensions of frying pans as plotted

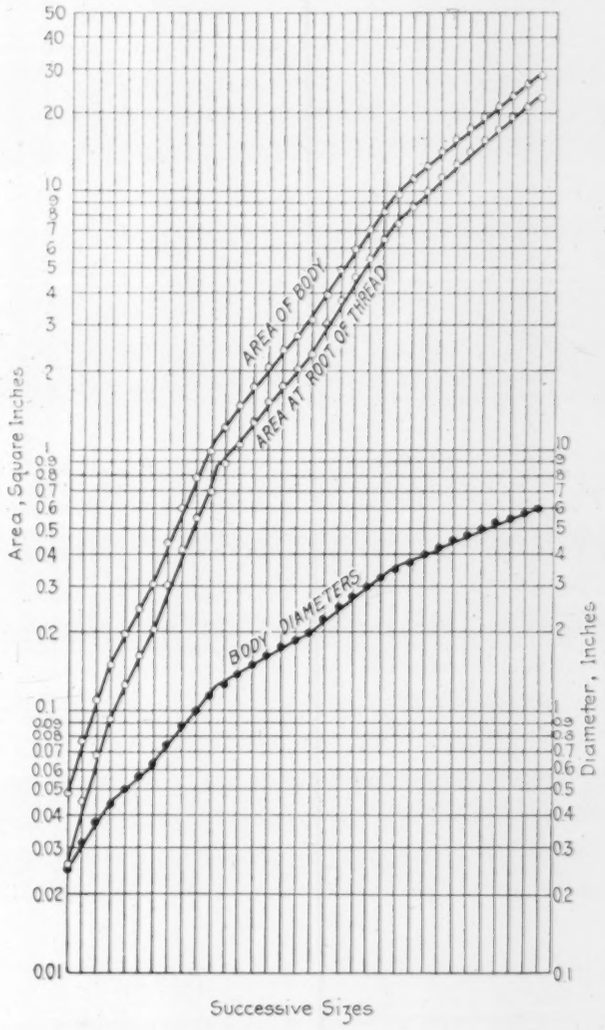


FIG. 10 U. S. STANDARD BOLTS

in Fig. 3. Diameter is certainly the most significant dimension of a frying pan. After that would come depth, and after that the combination of dimensions which affect ability to stack different sizes or a number of the same size. The smallest diameter is 6 in., a very convenient number, actually the preferred $^6/_{12}$ or $^1/_2$. This size is used for such purposes as frying a single egg, a single chop, or other small quantities of food. The next size has a diameter of 8 in., another one of our unconsciously preferred numbers, and beyond that diameters increase by half-inches to a diameter of 10 in. Beyond this size the diameters increase by 1-in. increments.

If there is any significance to the diameter of a frying pan it must result from the fact that the area is proportional to the square of that dimension. The squares of the diameters, and therefore figures proportional to cooking area, are plotted against nominal sizes in Fig. 18. The most casual inspection shows that in all probability no law underlies the choice of these diameters, and one is driven to the conclusion that sizes of about the proportions made have been found useful and that they have been chosen to fall on the preferred half-inch and whole-inch intervals.

Let us assume for the sake of argument that a 6-in., an 8-in., and a 13-in. size are necessary and that the cooking area is the underlying, governing criterion in choice of size. Let us also assume that six sizes are required between the 8-in. and the 13-in.

sizes. The simplest possible arrangement would result if we used diameters consistent with a straight line drawn through the 8-in. and 13-in. points in Fig. 18. The resultant areas and diameters are given in Table 1 for ready comparison with the actual commercial diameters.

TABLE 1 COMPARISON OF CALCULATED AND COMMERCIAL DIAMETERS OF FRYING PANS

Nominal Size	Area	Diameter	Commercial Diameter
0	64.0	8.00	8.0
1	73.5	8.56	8.5
2	84.0	9.16	9.0
3	96.5	9.83	9.5
4	111.0	10.53	10.0
5	128.0	11.31	11.0
6	147.0	12.12	12.0
7	169.0	13.00	13.0

It is at once apparent that the diameters corresponding to the smooth line of Fig. 18 are most inconvenient numerical values in

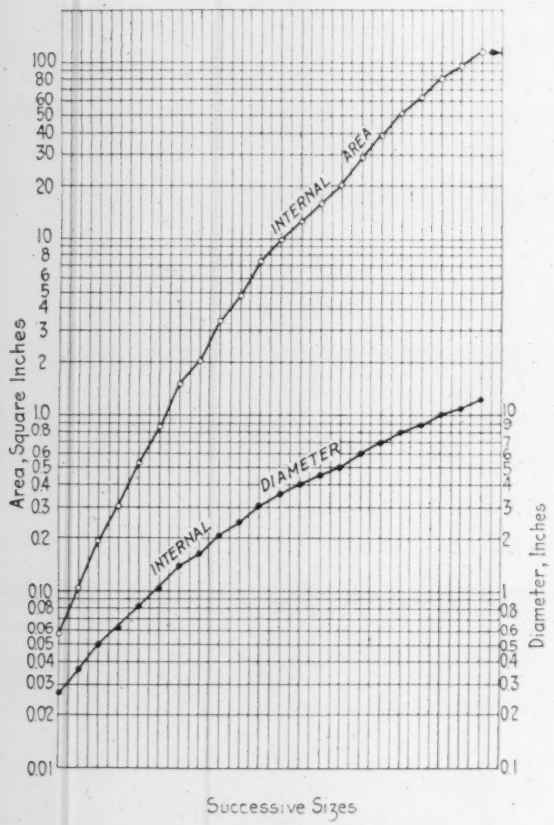


FIG. 11 STANDARD WROUGHT-IRON PIPE

comparison with the more commonly used numerical values which represent the actual commercial diameters. On the other hand, it is probably true that the resulting sizes are far more rational and would prove of greater use value, if there were any means of measuring such use value, since each size bears a certain definite constant relation to that which precedes it and that which follows it in the series. It is possible that a still better result could be obtained by using two different slopes between the two extremes so that diameters increased more slowly at the start and more rapidly later. Such an arrangement would correspond more nearly to present commercial sizes.

Now suppose for a moment that instead of using such values as even inches and half-inches we had at some time arbitrarily decided to give preference to, let us say, the curious numbers 8, 8.5, 9.2, 9.8, 10.5, 11.3, 12.1 and 13. If, under those circumstances, we developed a set of diameters for frying pans as given in the third column of Table 1 we should have driven ourselves into the situation illustrated by Table 2.

Obviously, we would not hesitate to round out the calculated values to the preferred values, and the frying pans built upon the preferred-number diameters would probably have just as great a use value as would pans built upon the calculated diameters.

As another example of the use of preferred numbers, consider

TABLE 2 COMPARISON OF CALCULATED AND PREFERRED DIAMETERS OF FRYING PANS

Calculated Diameter	Preferred Numbers
8.00	8.0
8.56	8.5
9.16	9.2
9.83	9.8
10.53	10.5
11.31	11.3
12.12	12.1
13.00	13.0

the matter of wrought-iron and steel pipe sizes. This material is sold in several different "weights" or wall thicknesses, additional thickness being obtained in most cases at the expense of internal diameter. In order to simplify matters to the greatest possible extent only one weight will be considered, namely, Standard Full Weight, and only such sizes will be used as are commonly sold on the basis of nominal inside diameter, that is, sizes up to and including 12-in. pipe. The sizes in which such pipe is graded are designated in inches and fractions of inches and refer to a nominal inside diameter, not to a real diameter. Table 3 will indicate the extent to which the nominal diameter is purely a fictitious designation.

TABLE 3 NOMINAL AND APPROXIMATE ACTUAL PIPE SIZES

Nominal Diameter, in.	Decimal Equivalent of Nominal Diameter, in.	Approximate Internal Diameter, in.
1/8	0.125	0.269
1/4	0.250	0.364
3/8	0.375	0.493
1/2	0.500	0.622
3/4	0.750	0.824
1	1.000	1.049
1 1/4	1.250	1.380
1 1/2	1.500	1.610
2	2.000	2.067
2 1/2	2.500	2.469
3	3.000	3.068
3 1/2	3.500	3.548
4	4.000	4.026
....	.....	.....
....	.....	.....
....	.....	.....
10	10.000	10.192
11	11.000	11.000
12	12.000	12.090

It is of interest to note that while we purchase such pipe in terms of even inches and fractions of inches, what we really purchase is pipe having internal diameters designated by figures which are apparently just as inconvenient as any of those which were worked out for frying-pan diameters. We are thus in fact using figures of

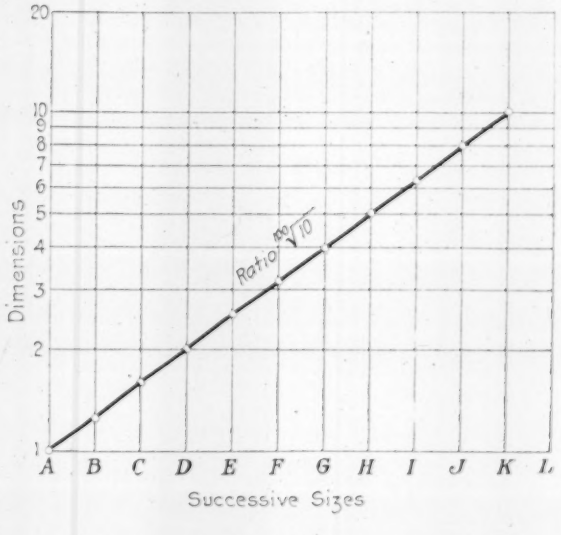


FIG. 12 GRAPH OF SIZE SERIES WITH RATIO $\sqrt[100]{10}$

this same form and sort but disguising them in order to express sizes in our preferred-number system.

Pipes are used principally as conveyors of liquids and gases and the significant dimension is the internal diameter, since this determines the cross-sectional area and therefore the carrying capacity of the pipe. Inspection of Fig. 11 shows a rather ordered progress of cross-sectional area from the smallest to the largest pipe sizes. It is probable that there was originally some reason back of the variations from exact order in successive sizes and areas. Possibly it had something to do with thickness of material available, or with some necessary relation between internal and external diameters;

or, more remotely, it may have had something to do with strength against bursting.

However, it should certainly be possible to make pipe to areas such as those indicated by the straight lines drawn on Figure 19. If this were done, the actual internal diameters would be as indicated by the other series of lines on the same figure. Inspection of the locations of the points representing the actual present-day diameters with reference to their proximity to the new-diameter lines will show that the new diameters required will not vary greatly from those actually in use. The variation appears to be of a much smaller order than was found in the study of frying pans.

If one objected to designating pipes in terms of these odd actual internal diameters, it would be perfectly possible to use the same sort of fiction which we now use under exactly the same conditions.

Examples of these sorts could be produced in almost endless variety, but it seems as though those just cited are sufficient to illustrate the points under discussion. We do use preferred numbers now, and very often these preferred numbers are used in a purely nominal sense while the real size dimensions are expressed in unwieldly decimal fractions. In some cases this is so extreme that we give these inconvenient decimal fractions special designations so that we will not have to deal with the numbers themselves. Such a case has just been considered in connection with pipes. Many others exist. Thus a No. 22 copper wire means something to almost every engineer, and yet there are very few who know that a No. 22 copper wire has a diameter of 0.0253 in. And why should they when the convenient round number 22 meets all ordinary needs and when exact diameter and area can always be obtained from a gageable if needed?

Unfortunately our preferred numbers are most irrationally related from many points of view. This follows directly from our conventional use of the inch and foot and from the way in which our system of numbers is built up. The effect of the inch and foot is illustrated in Fig. 20, in which a length of 12 in. is laid out to an arbitrary scale with certain preferred subdivisions set in in such a way that the length of the subdivision line represents the order of preference. It is apparent that any series of sizes which starts with dimensions less than one inch and ends with dimensions expressed in feet, inches, and fractions of an inch must almost certainly be made up on steps of most varying mathematical character.

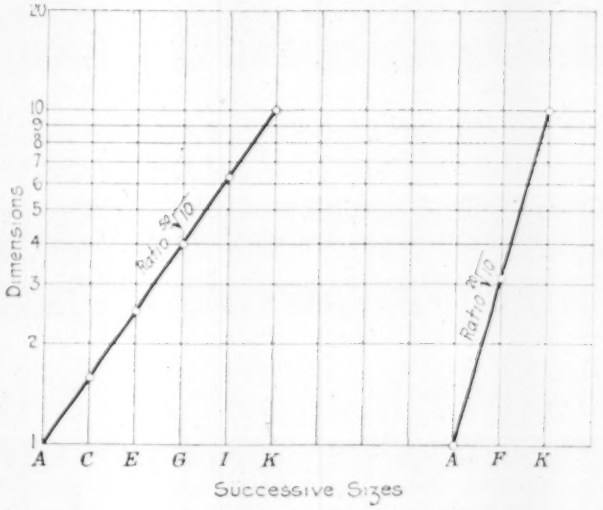


FIG. 13 GRAPHS OF SIZE SERIES HAVING RATIOS $\sqrt[50]{10}$ AND $\sqrt[20]{10}$

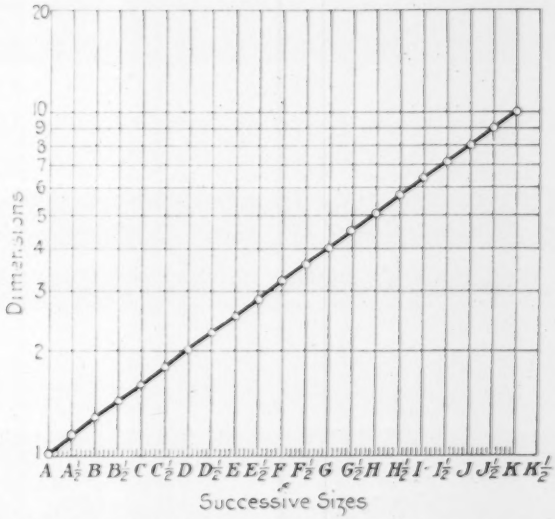


FIG. 15 SHOWING METHOD OF INTERPOLATING SIZES IN A SERIES

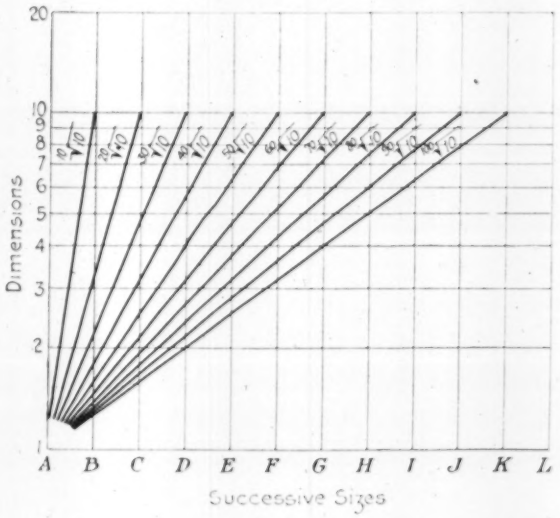


FIG. 14 SIZES AVAILABLE WHEN SERIES WITH DIFFERENT RATIOS ARE EMPLOYED

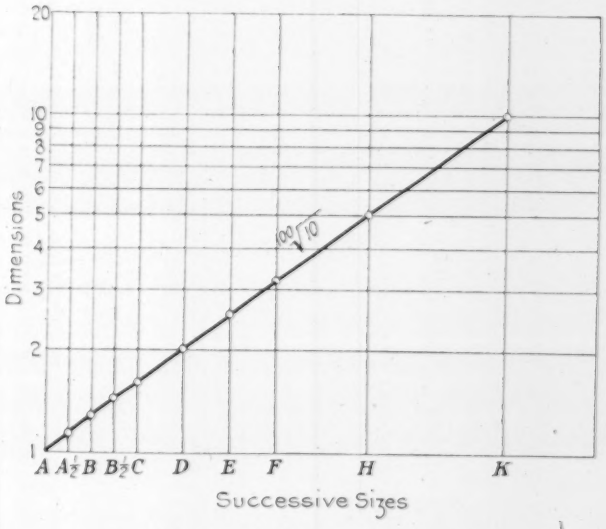


FIG. 16 UNEVEN SUBDIVISION OF SIZES

CONSTRUCTION OF GEOMETRICAL SERIES

Again, our system of numbers is itself basically peculiar. The logical steps of progression from 1 to 10 are by units or by simple or fractional multiples of units. The tendency is always toward even steps and there are surprisingly few possibilites. Thus we may use the following:

1, 10
1, 5, 10
(1, 2.5, 5, 7.5, 10)
1, 2, 4, 6, 8, 10
1, 2, 3, 4, 5, 6, 7, 8, 9, 10

These series are all arithmetical, and any attempt to arrange a geometrical series between 1 and 10 leads immediately to complicated, or at least inconvenient, decimal fractions.

Above 10, conditions are somewhat better in that there are numerous geometrical series yielding simple numbers, such as—

10, 20, 40, 80, 160, 320, etc.
10, 30, 90, 270, 810, etc.
10, 40, 160, 640, etc.
10, 50, 250, 1250, etc.

but it is obvious that the increase of value in the first series, which

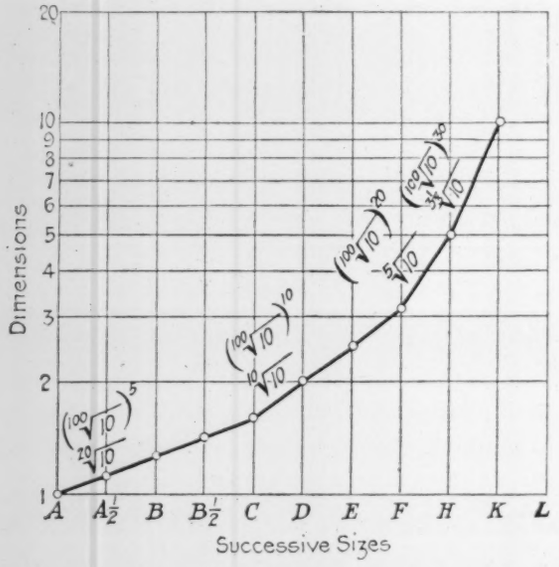


FIG. 17 DIMENSIONS FROM FIG. 16 PLOTTED WITH NOMINAL SIZES EVENLY SPACED

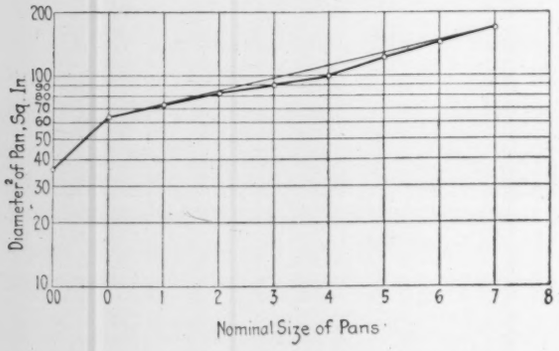


FIG. 18 SQUARES OF DIAMETERS OF FRYING PANS PLOTTED AGAINST NOMINAL SIZES

is characterized by the slowest rate of increase, is exceedingly rapid.

With the exception of such geometrical series one is limited to arithmetical series in developing steps of such character as to yield simple even numerals. One may progress by ones, twos, threes, fours, fives, etc., up to any desired value and thus develop any number of arithmetical series. But any attempt to develop geometrical series other than those just indicated leads immediately to fractional numbers.

These are the facts with which we are confronted, and, even if it be assumed that we can and possibly may change our system of measurement, it seems foolish to suppose that we will ever change our system of numbers. It looks, therefore, as though we may as well make up our minds to do the best we can with what we have.

The Germans have an official system of measurement which coincides in arrangement with the system of numbers. They therefore seem to have only one problem to solve where we have two. The truth of the matter is that in many cases they also have two, but there are enough cases in which they have only the one so that they can confine their attention largely to those cases for the time being. The movement to adopt preferred numbers may be regarded as an effort to evolve a number system better suited to our technical needs than the present system. Of necessity it is expressed in terms of our present system and as a result it appears at a disadvantage.

The Germans have two sets of preferred numbers and, the authors are informed, these numbers are now in use to a limited extent. The first is a set of "standard diameters," and was adopted before the recent development of the more general "preferred numbers." The second is built up on the 80th root of 10, and is like the one discussed in connection with Figs. 12 to 17. The method of construction is best illustrated by writing down the numerical terms of such series. These values are given in Table 4 for all series between that with ratio $\sqrt[5]{10}$ and that with ratio $\sqrt[80]{10}$.

TABLE 4 PREFERRED-NUMBER SYSTEM ADOPTED IN GERMANY—EXACT VALUES

Ratio = $\sqrt[5]{10}$ = 1.585		Ratio = $\sqrt[10]{10}$ = 1.259		Ratio = $\sqrt[20]{10}$ = 1.122		Ratio = $\sqrt[40]{10}$ = 1.059		Ratio = $\sqrt[80]{10}$ = 1.029	
Term	Numerical Value	Term	Numerical Value	Term	Numerical Value	Term	Numerical Value	Term	Numerical Value
0	1.000	0	1.000	0	1.000	0	1.000	0	1.000
..	....	..	....	..	....	..	....	1	1.029
..	....	..	....	..	....	1	1.059	2	1.059
..	....	..	....	..	....	..	....	3	1.090
..	....	..	....	1	1.122	2	1.122	4	1.122
..	....	..	....	..	....	..	....	5	1.155
..	....	..	....	..	....	3	1.189	6	1.189
..	....	..	....	..	....	..	....	7	1.123
..	....	1	1.259	2	1.259	4	1.259	8	1.259
..	....	..	....	..	....	..	....	9	1.296
..	....	..	....	..	....	5	1.334	10	1.334
..	....	..	....	..	....	..	....	11	1.373
..	....	..	....	3	1.413	6	1.413	12	1.413
..	....	..	....	..	....	..	....	13	1.454
..	....	..	....	..	....	7	1.496	14	1.496
..	....	..	....	..	....	..	....	15	1.540
1	1.585	2	1.585	4	1.585	8	1.585	16	1.585
..	....	..	....	..	....	..	....	17	1.631
..	....	..	....	..	....	9	1.679	18	1.679
..	....	..	....	..	....	..	....	19	1.728
..	....	..	....	5	1.778	10	1.778	20	1.778
..	....	..	....	..	....	..	....	21	1.830
..	....	..	....	..	....	11	1.884	22	1.884
..	....	..	....	..	....	..	....	23	1.939
..	....	3	1.995	6	1.995	12	1.995	24	1.995
..	....	..	....	..	....	..	....	25	2.054
..	....	..	....	..	....	13	2.113	26	2.113
..	....	..	....	..	....	..	....	27	2.175
..	....	..	....	7	2.239	14	2.239	28	2.239
..	....	..	....	..	....	..	....	29	2.304
..	....	..	....	..	....	15	2.371	30	2.371
..	....	..	....	..	....	..	....	31	2.441
2	2.512	4	2.512	8	2.512	16	2.512	32	2.512
..	....	..	....	..	....	..	....	33	2.585
..	....	..	....	..	....	17	2.661	34	2.661
..	....	..	....	..	....	..	....	35	2.738
..	....	..	....	9	2.818	18	2.818	36	2.818
..	....	..	....	..	....	..	....	37	2.901
..	....	..	....	..	....	19	2.985	38	2.985
..	....	..	....	..	....	..	....	39	3.073
..	....	5	3.162	10	3.162	20	3.162	40	3.162
..	....	..	....	..	....	..	....	41	3.255
..	....	..	....	..	....	21	3.350	42	3.350
..	....	..	....	..	....	..	....	43	3.447
..	....	..	....	11	3.548	22	3.548	44	3.548
..	....	..	....	..	....	..	....	45	3.652
..	....	..	....	..	....	23	3.758	46	3.758
..	....	..	....	..	....	..	....	47	3.868
3	3.981	6	3.981	12	3.981	24	3.981	48	3.981
..	....	..	....	..	....	..	....	49	4.097
..	....	..	....	..	....	25	4.217	50	4.217
..	....	..	....	..	....	..	....	51	4.340
..	....	..	....	13	4.467	26	4.467	52	4.467
..	....	..	....	..	....	..	....	53	4.597
..	....	..	....	..	....	27	4.732	54	4.732
..	....	..	....	..	....	..	....	55	4.870
..	....	7	2.015	14	5.012	28	5.012	56	5.012
..	....	..	....	..	....	..	....	57	5.158
..	....	..	....	..	....	29	5.309	58	5.309
..	....	..	....	..	....	..	....	59	5.464
..	....	..	....	15	5.623	30	5.623	60	5.623
..	....	..	....	..	....	..	....	61	5.788
..	....	..	....	..	....	31	5.957	62	5.957
..	....	..	....	..	....	..	....	63	6.131
4	6.310	8	6.310	16	6.310	32	6.310	64	6.310
..	....	..	....	..	....	..	....	65	6.494
..	....	..	....	..	....	33	6.683	66	6.683
..	....	..	....	..	....	..	....	67	6.879
..	....	..	....	17	7.079	34	7.079	68	7.079
..	....	..	....	..	....	..	....	69	7.286
..	....	..	....	..	....	35	7.499	70	7.499
..	....	..	....	..	....	..	....	71	7.718
..	....	9	7.943	18	7.943	36	7.943	72	7.943
..	....	..	....	..	....	..	....	73	8.175
..	....	..	....	..	....	37	8.414	74	8.414
..	....	..	....	..	....	..	....	75	8.660
..	....	..	....	19	8.913	38	8.913	76	8.913
..	....	..	....	..	....	..	....	77	9.173
..	....	..	....	..	....	39	9.441	78	9.441
..	....	..	....	..	....	..	....	79	9.716
5	10.000	10	10.000	20	10.000	40	10.000	80	10.000

A casual inspection of Table 4 shows that the series with ratio $\sqrt[10]{10}$ contains all the terms comprised in the series with ratio $\sqrt[5]{10}$ and in addition one term which is the geometrical mean between every two of those in the simpler series. Similarly, the series with ratio $\sqrt[20]{10}$ contains all those in the series with ratio $\sqrt[10]{10}$ with one additional term between every two of those occurring in

the latter series. The same sort of thing must hold, no matter how far one carries the construction of such series.

Obviously, if one wished to construct a set of models with a small number of steps or sizes, he would use some or all of the values in the $\sqrt[10]{10}$ series, or possibly even drop back to the $\sqrt[5]{10}$ series. If more sizes were wanted the $\sqrt[20]{10}$ series or the $\sqrt[40]{10}$ or the $\sqrt[80]{10}$ would be used as required.

This gives several sets of preferred numbers, all of which, however, belong to one family.

The Germans then take one further step and round off these preferred numbers, making 1.259 into 1.2; 1.585 into 1.6; etc. This gives the final set or sets of preferred numbers. Such sets are illustrated in Table 5, from which the method of construction will be obvious when studied in connection with Table 4.

TABLE 5 PREFERRED-NUMBER SYSTEM ADOPTED IN GERMANY—SIMPLIFIED VALUES

Values from 1 to 48				Values from 50 to 500			
Series 1	Series 2	Series 3	Series 4	Series 1	Series 2	Series 3	Series 4
1	1	1	1	...	50	50	50
...	1.2	1.2	1.2	...	...	...	52
1.6	1.6	1.6	1.6	...	...	56	56
...	2	...	2	...	...	...	60
2.5	2.5	2.5	2.5	64	64	64	64
...	3	...	3	...	...	...	68
...	...	3.5	3.5	...	...	72	72
4	4	...	4	...	...	...	75
...	...	4.5	4.5	...	80	80	80
...	5	...	5	...	...	...	85
...	...	5.5	5.5	...	...	90	90
6	6	...	6	...	...	...	95
...	...	7	7	100	100	100	100
...	8	...	8	...	...	...	105
...	...	9	9	...	...	112	112
10	10	10	10	...	...	...	118
...	...	11	11	...	125	125	125
...	12	12	12	...	...	...	132
...	...	...	13	...	...	140	140
...	...	14	14	...	...	...	150
...	...	...	15	160	160	160	160
16	16	16	16	...	...	...	170
...	...	...	17	...	...	180	180
...	...	18	18	...	...	...	190
...	...	...	19	...	200	200	200
...	20	20	20	...	...	...	210
...	...	...	21	...	...	225	225
...	...	22	22	...	...	...	240
...	...	...	24	250	250	250	250
25	25	25	25	...	...	...	265
...	...	...	26	...	...	280	280
...	...	28	28	...	...	...	300
...	...	...	30	...	320	320	320
...	32	32	32	...	...	...	340
...	...	...	34	...	...	360	360
...	...	36	36	...	...	...	380
...	...	...	38	400	400	400	400
40	40	40	40	...	...	...	420
...	...	...	42	...	...	450	450
...	...	45	45	...	...	...	480
...	...	...	48	...	500	500	500

The authors believe that it may be a mistake to round out the numbers in these tables instead of preserving the original values. The original values are the exact values, and the extent of rounding in some cases is so great as to entirely mask the original value. If one regards the adoption of preferred numbers as the adoption of a new number system, much can be said in favor of preserving the peculiar decimal fractions. However, only experience can prove the correctness or incorrectness of such practice.

Application of Preferred-Numbers System to Units of Measurement

Any attempt to apply such a system of numbers to our units of measurement immediately introduces a complication. The decimal fractions do not lend themselves readily to use with feet and inches in the way in which we now use, or think we use, those dimensions. However, it has been shown already that in many cases we are now dealing with decimal fractions in some of our most common articles of commerce, and there is no reason to suppose that we could not extend this practice if the results to be achieved warranted it. If we adopted the inch as a standard of length, for instance, and used decimal fractions of inches and multiples by tens we should have a system with many of the conveniences of the metric system.

After all, commerce is actually conducted as much in terms of nominal sizes as in terms of actual or approximate dimensions, so that no difficulty need be anticipated in that direction. Production at the present time is effected largely in terms of gages, and it is certainly just as easy to produce gages to check a dimension equal to, say, 1.585 as it is to construct a gage to check a dimension equal to 1.750, that is, 1¾ in. or 1 ft. 9 in. It would seem as though no great difficulties would be introduced into production or manufacture by the adoption of such decimal fractions. The only other function needing consideration is that of design. The designer in most cases works in terms of decimal fractions anyway, and with our present system is confronted with the necessity of converting his final results into the conventional fractions of an inch. Certainly he ought not to complain if a system of measurement expressed in decimal fractions is adopted.

Let us now return to the graphs of actual sizes of commercial products as given in Figs. 1 to 11, 18, and 19. Study of such graphs will show that those products which are largely used as components of manufactured or fabricated articles, such as bar steel, bolts, structural shapes, wire, etc., are generally made

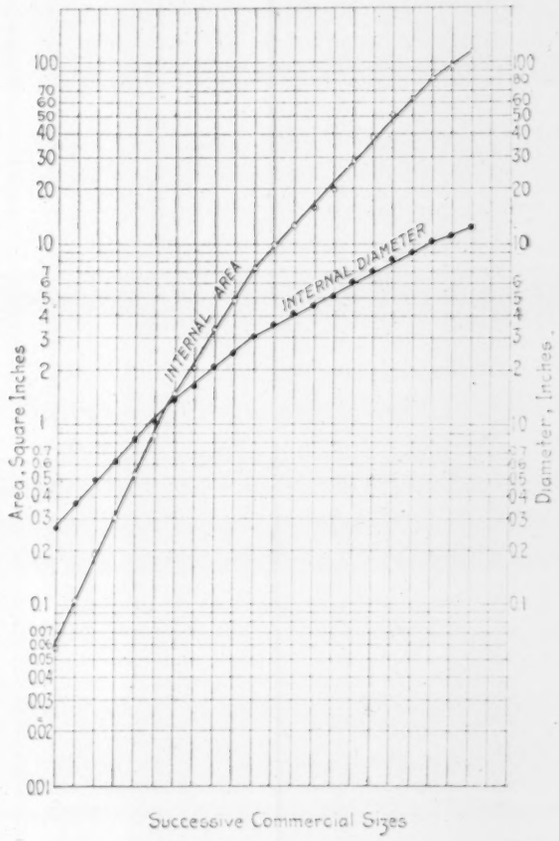


FIG. 19 STANDARD WROUGHT-IRON PIPE
(Points represent actual diameters and areas as now made.)

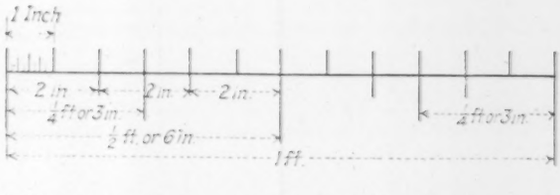


FIG. 20 LENGTH OF ONE FOOT SO SUBDIVIDED THAT LENGTHS OF DIVISION LINES REPRESENT ORDER OF PREFERENCE

in such sizes that the graph to semi-logarithmic coördinates is concave toward the horizontal axis. This means that in the larger sizes such materials are made to finer sizes (smaller steps) in a geometrical sense than they are in the smaller sizes. On the other hand, in the case of finished articles, such as household utensils, containers, machines of various sorts, etc., there is a greater tendency for the graph to flatten out or to become convex toward the horizontal axis. This indicates a tendency toward more uniform spacing throughout the line and in some cases toward wider spacing, in a geometrical sense, in the larger sizes.

Such tendencies as these may not be lost sight of in any effort to rationalize sizes by the adoption of preferred numbers. It may be that we now produce an excessive number of sizes in certain products and that we would actually save in the long run by producing fewer, but such matters require long and detailed study before conclusions can be drawn.

There is a further thought which should be kept in mind during all efforts to adopt preferred numbers. Materials as used in production are basically dimensioned to meet certain loading requirements. It happens that physical dimensions appear in several different ways in the formulas which are involved, particularly with reference to their exponents.

As an illustration of the significance of this, strength in tension or compression varies with the square of the diameter in the case of a solid circular section, but strength with respect to bending varies as the cube of the diameter. If we imagine a set of preferred numbers in use and further imagine that round steel stock is rolled to preferred diameters, it hardly seems possible that one set of preferred diameters can give equally desirable variations of its squares and its cubes. When one considers the further complications which are introduced when other types of loading are brought into consideration, the case appears complex indeed.

Such difficulties may prove to be more apparent than real, but the underlying ideas should be borne in mind in any detailed study of this subject.

Possibilities in Simplification of Design

Attention thus far has been concentrated largely on size as a finished or completed proposition with little reference to the mechanism of design. No small part of the saving to be expected should accrue from simplification of design. This matter has been sparingly treated in the rather meager literature of this subject and a few very interesting studies have been recorded. In particular, a paper by Erich Hoffman published in *Mitteilungen des Normenausschuss der Deutschen Industrie*, February, 1920, contains two very interesting examples, one of these being a set of eyebolts.

The collar diameter of the smallest eyebolt is taken as the basic dimension, and for successively larger bolts this is increased in the ratio $\sqrt[10]{10}$ for the smaller range of sizes, and in the ratio $\sqrt[20]{10}$ for the larger range of sizes. Other dimensions of each eyebolt are obtained by taking its collar diameter as a starting point and multiplying by factors differing with the dimension sought. The factor used for a given dimension (such as internal diameter of eye), however, is the same for all sizes of bolt, and the result is therefore a set of geometrically similar eyebolts. As a matter of fact, the Germans have gone one step further, in that, for the set of eyebolts in question, each dimensional multiplying factor is taken as one term in the series with the ratio $\sqrt[80]{10}$, and thus each of these factors is itself a preferred number.

This sounds like a very pretty piece of mathematical juggling in connection with machine design, but it really has a very deep practical significance. A designer need design and draw only one size of eyebolt if he is sure that a certain series can be applied. All other desired sizes can then be obtained by the simplest form of calculation or directly from a table. If there is doubt as to the applicability of one series, he may design and draw the two extreme sizes and the middle size, determine the applicability of any chosen geometrical series, and proceed by simple interpolation to tabulate dimensions for all sizes. A certain amount of caution is necessary in such proceedings and it is always best to draw at least the two extremes if one is in doubt as to the applicability of a given series. Hoffman points out a case in which certain handwheels were under consideration. A satisfactory result was obtained by grading the outer diameter according to the $\sqrt[20]{10}$, the thickness of the rim and spokes according to the $\sqrt[40]{10}$, and the diameter of the hub according to the $(\sqrt[80]{10})^3$. This looks extremely complicated, but if one draws the largest and smallest handwheels, plots the points on semi-logarithmic paper and draws straight lines between, the job is finished.

German authors have been quite enthusiastic over the fact that geometrical series, and particularly geometrical series with ratios equal to roots of 10, have proved widely applicable to design and sizing as now carried out. They seem to emphasize the ease with which the series based on $\sqrt[80]{10}$ can be fitted into existing designs. At first sight it seems as though such applicability represented a most remarkable coincidence, but there is really much behind the phenomenon.

In the first place, human beings accept geometrical ratios in preference to arithmetical when the results are presented in such fashion that the mathematical construction is not in evidence. This is a phenomenon well known to psychologists and one which has been extensively tested. Examples could be cited from many different human activities, but consideration of size is sufficient for the present purpose. The normal human being, in developing a series of sizes, starts out with small increments, enlarging them as he increases the sizes. He thus unconsciously approximates some geometrical series or some combination of geometrical series.

In the second place, one can obtain practical approximations to all the numbers there are by using a sufficiently great number of series based on roots of ten.

The preference for the series with the $\sqrt[80]{10}$ ratio is probably due to the large number of terms in the series, and to the binary structure of the number 80, which contains 2 as a factor four times. This last feature makes this series fit in with many existing sizes since, as has been pointed out, the binary principle (successive division or multiplication by 2) has been extensively used in fractional and in many other series of "preferred numbers" which have been developed and used more or less unconsciously through a long period of time. This feature also makes it possible, if changing industrial conditions make such a development desirable, to double the number of terms in a 5-, a 10-, a 20-, or a 40-series, or in any part of such a series. Furthermore, it may happen that this series represents approximately the path chosen by an uninfluenced human being and is therefore mathematically located in accordance with the theory of probability.

In presenting this paper the authors have attempted to picture the present status of the preferred-number idea and to do it in such a way as to point out its advantages and also its complications and dangers. The authors themselves hold no brief for preferred numbers, but they do believe that the idea indicates possibilities of simplification and elimination of waste of such magnitude that thorough investigation is justified.

The American Engineering Standards Committee is very much interested in the subject of preferred numbers, or Standard Numbers, as the tendency is now to term them, on account of the very generalized way in which the proposal affects many standardization projects. If after study and wide discussion the preferred-numbers method proves to be a sound and rational scheme, it will provide a systematic and flexible tool for settling the question of standard sizes for many component parts, if not for complete structures and machines.

The Committee is coöperating in the current phase of this topic by getting in touch with engineers and industrial experts in diverse fields to which the subject is related, and arranging discussions by leading representatives of some of the following fields: Electrical manufacturing and construction; building design and construction; manual and automatic telephony and telegraphy; governmental research and development work; railway construction and manufacturing practice; hardware; the lumber trade; bolts, nuts and rivets; military ordnance; machine tools; gages; automotive products; structural-steel sections; illuminating practice; and management.

The American Engineering Standards Committee has conducted an inquiry as to the use of the preferred-numbers method abroad. Not all the returns are in, but it is known that the system is already in use in Germany. A general preferred-numbers standard is up for adoption by the Commission Permanente de Standardisation in France, and the system has been used in two French detail standards, one on tool holders for lathes and other machine tools, and the other for aluminum plates, strips, rolled sections, and tubes. The Dutch have the subject up for consideration by their main committee, and may issue a standard; the Austrians expect to adopt the German Standard on the subject, and consider the plan to be very important in its relation to international standardization, in improving the exchangeability of products. The Swedes also think the subject should be considered internationally, and feel that their past work could have been guided and facilitated by some sort of rational preferred-number series. The Swiss are awaiting further manufacturing opinion before proceeding to the development of a standard. The Norwegians express themselves as definitely interested. Everything considered, the coming year is likely to see developments of great importance in this relation.

Steam Distribution in the Locomotive

By GEORGE H. HARTMAN,[1] CLEVELAND, OHIO

This paper gives particulars regarding a new sleeve-valve arrangement for locomotives, designed by Charles J. Pilliod, that can be applied to old engines, either simple or compound. Among other things, it is claimed that the new arrangement

(1) Makes it possible to effect in the locomotive a steam distribution and economy superior to that obtained in the Corliss stationary engine, along with a reduction in the degree of superheat now carried;

(2) Eliminates causes producing lame engines, as well as lubrication troubles now experienced with plain valves; and

(3) Makes it impossible for the engineer to cause the cut-off to occur earlier than at its most economical running position.

THIS paper deals primarily with the research work of Charles J. Pilliod, one of the pioneers in locomotive valve and valve-gear design. Mr. Pilliod has recently designed a new valve that has much merit, and one that will, in the opinion of the author, establish many new precedents. While final tests have not yet been made, it is nevertheless believed that the ideas involved are of such importance to the railroad world that they should be disclosed and made the subject of discussion.

In stating the claims that are made for the new valve and analyzing them as to the theory involved, the author has no intention of discrediting any other device that he may find it necessary to mention. It has been thought desirable, however, to raise as many pertinent points as possible in order to stimulate friendly criticism of the conclusions which he reaches, and also to emphasize the fact that there is need in the locomotive field for economy-increasing factors.

A fairly complete analysis of the results produced by the three leading types of valve gears has been found necessary, inasmuch as the use of the new valve arrangement does away with the use of the valve gear as a cut-off-producing medium.

True Efficiency

After the steam is in the cylinder there is but one way to increase the utilization of the heat units it contains, and that is to lower its terminal temperature by expansion. The locomotive in cutting off the steam at 25 per cent of the stroke and releasing at 60 per cent produces 2.4 expansions, neglecting clearance. If the expansion is carried to the end of the stroke there will be four expansions for the same point of cut-off, or an approximate increase of 33 per cent in the utilization of the heat units. This percentage of increase, minus the gain due to maintaining the steam line past the point of release, on account of the back pressure, would be the gain that we could expect to obtain from the increased expansion, other conditions being equal.

Running non-condensing, the simple Corliss engine shows a saving of 25 to 30 per cent over the simple automatic engine, and a saving of 40 per cent over the simple throttling engine. This economy is due entirely to the fact that the release point is made to occur at from 85 to 90 per cent of the stroke at all points of cut-off. It is not possible, however, to use the Corliss design in locomotive practice due to its limitations as to speed, but it does point out the path that must be followed if we ever expect to utilize more of the energy that is available.

Operation of the Pilliod Sleeve Valve

The Pilliod locomotive sleeve-valve arrangement consists of two moving sleeves, or rather a plug and a sleeve, together with a cut-off-controlling bushing. The inside sleeve or plug is moved through a certain constant travel, the amount of which depends upon the valve events that are desired. This plug is actuated by the reversing mechanism, being driven by the radius rod of the valve gear. For application to old power it is never necessary to exceed 4 in. of valve travel. Either the travel of the lever in the cab can be limited or the throw of the return crank reduced to accomplish this result. The outside sleeve is driven from the lap-and-lead lever of the engine, which imparts to it a travel generally around $2^1/_2$ in.

The operation is as follows: The plug and the sleeve moving thereon, by receiving constant travels at all of the points of cut-off, produce at all times constant valve events, including that of the maximum point of cut-off. All valve events are exactly equal on both ends and the same in the forward as in the back motion, as will be brought out in detail later. Changing of the point of cut-off is effected by moving the cut-off-controlling bushing, which is a sliding bushing manually or air-controlled by the engineer. This bushing together with its control linking is shown in Fig. 1.

It should be emphasized in this connection that the events of release and exhaust closure are not effected by the operation of the cut-off-controlling bushing, and also that they can be made to occur at any point that may be desired, up to and including the end of the stroke.

The sleeves are always in a perfect state of balance, even remaining so should ring leakage develop. The cut-off-controlling bushing is not only balanced as to steam pressure, but also against the sliding friction of the sleeves moving therein. This is made possible by linking up the control levers so that equal and contrary reactions are produced at all positions. By referring to Fig. 1 it will be seen that when the lever that controls this cut-off bushing is moved by the engineer, the two sections comprising it are either moved toward or away from each other, as the case may be. This opposing movement changes the port line on which the variable cut-off is effected. Exact balance is produced by reason of this contrary movement, as the sleeve imparts a push to one of the cut-off-controlling bushings and a pull to the other or vice versa. It will be seen that the reach-rod connection in the cab could in theory be disconnected and no movement of the cut-off bushing would result. Due to this exact balance it is possible for the engineer to unlatch the controlling lever in the cab, for it cannot move until he actuates it.

Referring to Figs. 1 and 2, it will be seen that the Pilliod sleeve valve can be applied to existing piston-valve engines by placing an adapter bushing in the chest that carries the new port lines required for the sleeve valve. This reduces the diameter of the valve slightly, but as the port opening that can be obtained is practically unlimited, no disadvantage results. It is possible to get $^5/_8$ in. admission opening and $1^3/_4$ in. exhaust opening at 25 per cent cut-off with only $3^1/_2$ in. valve travel. Increased valve travel will give a corresponding increase in the port openings that can be obtained. Where the sleeve valve is applied to new saddles or to old slide-valve engines that have been converted with a new piston-valve chest, this adapter bushing is not needed.

Results Produced by the Pilliod Sleeve Valve

The following advantages are claimed for the Pilliod sleeve valve:

a Elimination of the valve gear as a means for producing variable cut-off. This does away with the distortion now present in all valve gears, and in particular when the sleeve valve is driven by the Walschaerts, Baker, and other gears that receive their accelerated travel from a connection to the crank; as the rise and fall of the engine on its springs will not cause a change in the valve events. All causes producing lame engines are eliminated

b Unlimited amounts of port opening, both admission and exhaust, at any point of cut-off

c Elimination of lubrication troubles now experienced with plain valves

d Full expansion of the steam to the end of the stroke, regardless of the point of cut-off

[1] Chief Engineer, Cleveland Vending Machine Co. Assoc-Mem. Am. Soc.M.E.

For presentation at the Annual Meeting, New York, December 4 to 7, 1922, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. Slightly abridged. Copies of the paper may be obtained gratis upon application. All papers are subject to revision.

e All the compression eliminated; or all the compression desired obtained at any point of cut-off and independently thereof

f No preadmission noticed, regardless of the amount of lead

g Reduction in the degree of superheat now carried is possible with the new arrangement, with an increase in the economy effected and with a large reduction in the present maintenance expense

h Proper balancing of the Mallet compound is made possible, together with other advantages where the new arrangement is applied to compounds

i The new arrangement aids combustion, due to better draft, softer blasts, etc.

j Decreased reciprocating weights. The inside plug on a 14-in. by 46-in. chest weighs 154 lb. and the outside sleeve 146 lb., or a total of only 300 lb.

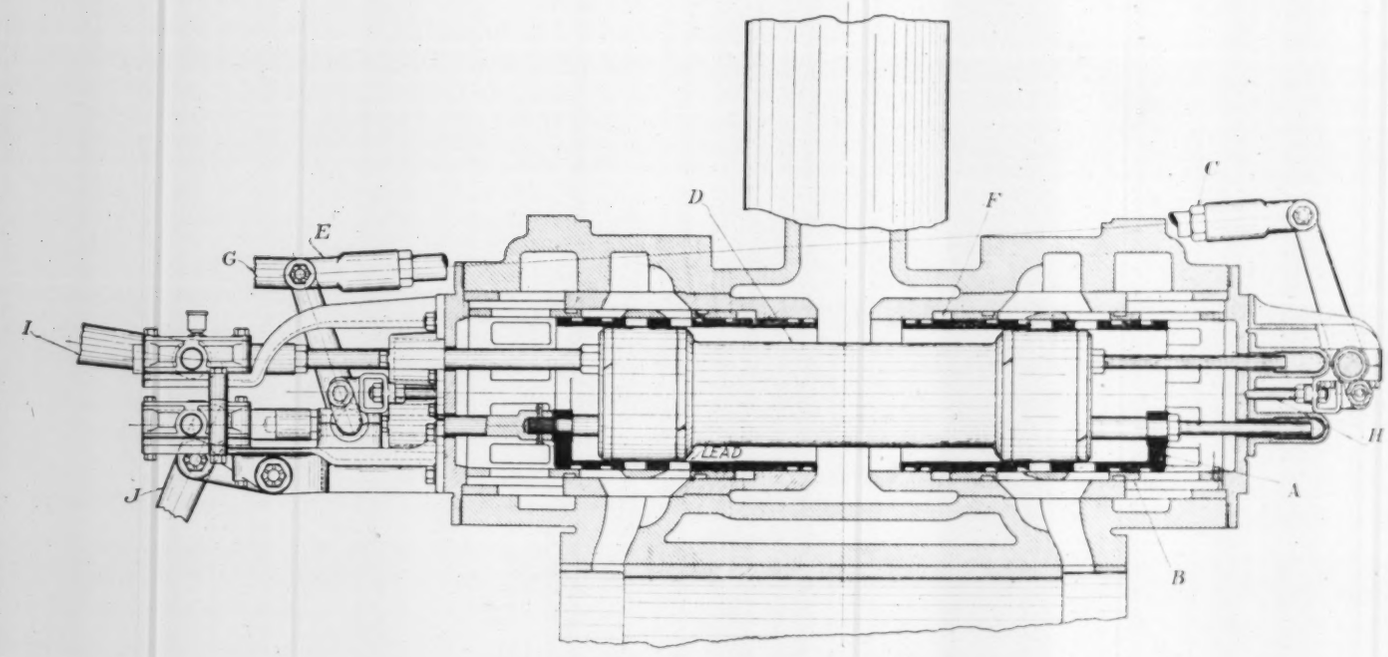


FIG. 1 THE PILLIOD LOCOMOTIVE SLEEVE VALVE

A—Moving sleeve traveling a constant distance of 2 1/2 in. and driven by combination lever *J*. Shaft connecting the two halves of this sleeve works through the inside plug valve *D*. Cut-off and release are produced entirely by this sleeve driven by the crosshead.

B—Cut-off is controlled by moving this bushing. A movement of 1 1/2 in. changes cut-off from 85 per cent to 25 per cent. Control either from reach rod or air cylinder.

C—Control rod by which cut-off-controlling bushing is adjusted.

D—Inside plug or spool driven by radius rod of valve gear. Has a constant travel of 4 in. for all events given below. This plug performs function of reverse; it does not effect the cut-off.

E—Due to the opposing travels of the cut-off-controlling bushings at each end, all ring-friction loads, etc., produce tension in this rod between the pins at either end. No stresses are carried to air cylinder or hand control (if latter is used).

F—Holes are drilled through the bridges into the exhaust that prevent pressure backing up into this pocket.

G—Connection to air-control cylinder or to reach rod and reverse lever in cab.

H—Two of these 7/8-in. rods connect to each cut-off-controlling bushing on the outer edge.

I—Radius rod of valve gear driving plug *D* through its 4 in. of travel.

J—Combination lever of valve gear driving the sleeve *A* through its 2 1/2 in. of travel.

Valve Events:

85 per cent cut-off; 96 per cent constant release; 85 per cent constant exhaust closure.

Full 1 3/4 in. port opening at 85 per cent cut-off in 17 per cent of stroke.

Full 7/8 in. port opening at 50 per cent cut-off in 4 per cent of stroke.

Full 5/8 in. port opening at 25 per cent cut-off in 2 per cent of stroke.

Full 1 3/4 in. exhaust opening, dwelling full open between 5 per cent and 60 per cent of stroke on the return travel of the piston at *all* points of travel.

Constant 1/16 in. preadmission at all points of cut-off with 3/8 in. lead.

NOTE: These valve events can be changed so that they will give any release at any point of cut-off.

k The placing of all engineers on a basis of equality. The proper minimum point of cut-off cannot be exceeded. The engine cannot be worked against itself

l When applied to existing piston-valve engines it is not necessary to make radical changes in the existing engine structure. When applied to most slide-valve engines, a specially designed piston-valve chest can be used that is also applicable for use with the standard inside-admission plug valve.

A study[1] of modern locomotive valve gears will lead one to doubt that there is any mechanical reason why any one gear will give more expansion, permit of more rapid opening of the ports, give wider port openings, or better steam distribution than any other, provided that the valve travel, lap, lead, etc., are the same in both cases. One gear might, under different conditions from those mentioned, produce a slightly better steam distribution, but the author is convinced that any outside valve gear can be designed to give any steam distribution that can be obtained by using any other valve gear. If this be true, how can any claim be made by the maker of a given valve gear for efficiency increases over any other? Possibly the Walschaerts types might give slightly better results along the full range of cut-off than the designs with the Randel reverse, on account of the more complete dissipation of the angularities. Further, it is the general opinion that the old Stephenson motion will produce a slightly better steam distribution than the outside valve gears now used.

To bring out the slight difference in the results obtained with various valve gears, the charts of Figs. 3 and 4 have been prepared. From these it will be noted that with equal valve travels the results do not vary to any considerable extent.

The question might be raised as to why these gears are so extensively used if greater economy is obtainable from the older forms of valve motion. The main reason is that the Walschaerts and the Baker designs permit of repairs being made more easily and of better designs being made than would be possible with the heavy type of inside gears, which cannot be easily used with the heavy modern power that we now have. Other factors, such as piston valves for superheated engines—requiring outside valve gears—must also have consideration. It is claimed by some that the Baker gear, by making use of the Marshall reverse, is possibly easier to build than the Walschaerts, which employs the expensive curved link.

Radical improvements in the maintenance of the initial valve settings are possible by changing the valve gear so that the accelerated travel, as well as the lap-and-lead travel, can be obtained from the crosshead. The crosshead-connected valve gears show great increase in economy, due to maintaining the efficiency that the engine had when new.

[1] The complete paper discusses the matter fully.

ANALYSIS OF THE CLAIMS MADE FOR THE PILLIOD SLEEVE-VALVE ARRANGEMENT

There are no limitations of any kind in the events produced by the new sleeve arrangement. This arrangement also eliminates all of the distortive features connected with valve gears regardless of what type of valve gear is used to drive the sleeve valve.

No Distortion of Valve Events Possible in the Sleeve-Valve Arrangement. The reasons why the new valve arrangement cannot be distorted and why it will remain square after any period of use, can be made the subject of an interesting analysis. If it could do no more than maintain the same valve events that are now obtained by the plain piston valve, its use would probably warrant the cost of application. The 8 to 21 per cent loss resulting from lame engines is a condition recognized by all who have given valve-motion design any attention whatsoever.

When the new sleeve-valve arrangement is applied to an old locomotive the same valve gear is used to drive it that was used with the valve removed (see Fig. 2). In the case of the sleeve arrangement, however, the valve gear ceases to be a valve gear in the strict sense of the word and becomes only a plain reversing device. The lap-and-lead motion of any outside valve gear of the Walschaerts or Baker types can never be distorted by the changing conditions in the setting of the engine.

Referring to Fig. 1, it will be seen that the event of cut-off is accomplished by the action of the outer sleeve closing in on the edge of the cut-off-controlling bushing. It will also be seen that the plug valve driven by the reversing device performs no part of this cut-off function. This condition makes the cut-off at all points purely one of a fixed relation between the combination lever-driven sleeve and the manually or air-controlled cut-off-controlling bushing. This being true, the cut-off can never be anything but in the 100 per cent square condition that the engine had when new. Even pin wear in the combination lever and the other connections will not cause a variance, as the lost motion due to pin clearance will be the same at both ends of the stroke.

The release will also always remain square, as the opening of the port is being accomplished through the fact that the plug valve is traveling at a high rate of speed when the piston, by reason of its being at the end of the stroke, is closely approaching a state of rest. The valve travel being constant at all points of cut-off, the action of the opening of the exhaust port is also constant. This permits of the correct setting being obtained, and the feet-per-minute travel of the valve being much greater than that of the piston, makes it possible for the accelerated travel to be greatly distorted without the ear being able to detect unequal exhausts. Another condition that practically eliminates the unequal exhausts due to distortion is that the release by occurring at 95 per cent of the stroke and upward so reduces the terminal pressure that even if exhaust lameness were present there would be little if any loss of efficiency.

The foregoing analysis shows that long periods of maintenance are possible when the sleeve-valve arrangement is applied to engines in which the accelerated travel is obtained from a connection to the crank. In the case of the crosshead-connected valve gears the maintenance conditions would not be increased over those now obtained by the use of such gears. But when we consider that of all the locomotives now in use, less than one hundred are equipped with crosshead-connected valve gears, we can appreciate the gain that will be derived from this feature of freedom from lameness when the new valve arrangement is applied to old power.

Unlimited Port Opening At Any Point of Cut-off. The new valve arrangement, consisting as it does of a pair of sleeves, each driven from a different source and each moving a greater or less distance, produces this form of travel. First the sleeves move as a unit and in the same direction, then one will follow with a retarding movement and the other will accelerate, then both will dwell; and finally they will move as a unit in the reverse direction, producing a period of maximum opening and then a rapid shearing closure by the sleeves again moving in the first direction. This means that the port opening at the working point of 25 per cent cut-off is obtained almost before the piston can be seen to move, and that by changing the valve travel this port opening can be made any amount desired. For instance, with $2^1/_2$ in. travel of the sleeve connected to the combination lever, we get $^5/_8$ in. port opening at 25 per cent cut-off, which is 100 per cent more than is now obtained. With an additional $^1/_2$ in. of sleeve travel we get $^3/_4$ in. port opening at 25 per cent cut-off. At full gear, with the $2^1/_2$-in. travel, the width of opening will equal that now obtained with the plain piston valve.

This excess port opening and the extreme rapidity with which the opening is effected means that one of the principal arguments in favor of early exhaust closure has been shattered, as the steam admission line can be maintained straight, even with the almost total absence of compression and preadmission. The restriction of the present valve design, in which never more than $^1/_{32}$ in. to $^1/_{16}$ in. acceleration is obtained with $^1/_4$ in. lead and 1 in. lap, produces a wire drawing effect at high speeds, and if the clearance space had to depend on the boiler for steam, the steam line of the indicator card would show a material dropping off. This wire-drawing, moreover, causes excessive initial condensation, which will not occur where the port opening is unlimited.

Unlimited Release Opening. The events produced by the constant-travel valve are all constant except that of cut-off. As the valve travel is not changed in proceeding from one point of cut-off to another, the same release that is given for full gear will

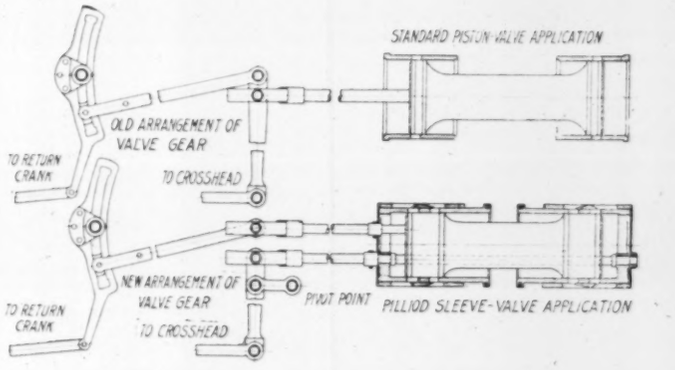
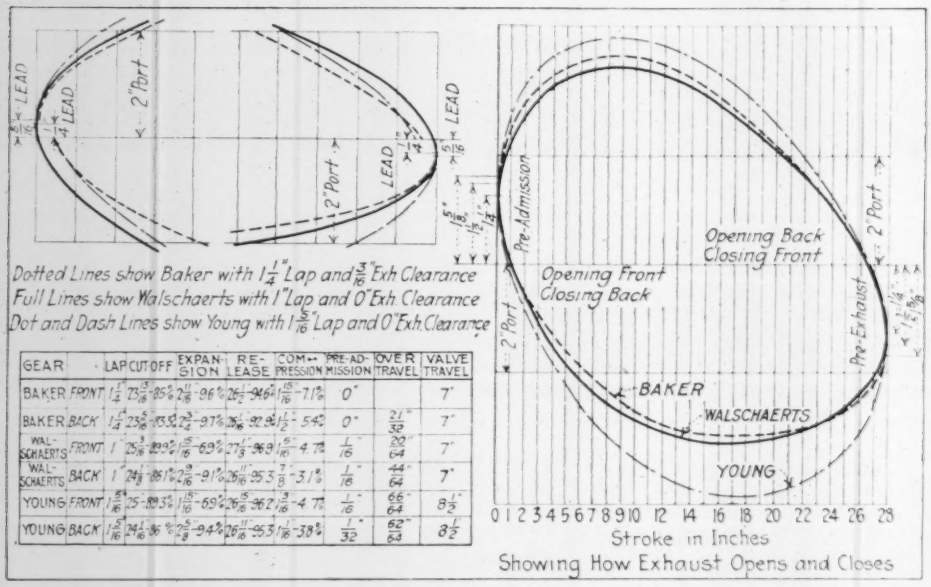


FIG. 2 CHANGES REQUIRED WHEN OLD LOCOMOTIVES ARE FITTED WITH PILLIOD SLEEVE VALVES

be had at all of the working points of cut-off. With the plain variable-travel piston valve, when the travel is shortened in order to get the earlier cut-off the release opening is at the same time restricted. A comparison of the events of the plain valve with those of the new Pilliod arrangement can be seen in Figs. 5 and 6. With the sleeve action above mentioned, full opening is obtained at the end of the stroke and within $1^1/_2$ in. travel of the piston, which opening is caused to persist up to 60 per cent of the return travel of the piston, at which point the closure starts and by the shearing action of the sleeves the valve rapidly closes at 95 per cent of the stroke, provided this is the point of release for which it is designed. This means that back pressure can be entirely eliminated if desired and all of the force produced applied to the crank as a turning moment.

Variable Relation of the Release to the Closure. A defect in the present design of plain variable-travel piston valves is that, with the exhaust line and line, exhaust closure must occur diametrically opposite to the point of release. As before stated, if the release is made to take place later by the addition of exhaust lap, then the closure will occur earlier. In the case of the Pilliod arrangement, anything desired can be given. If designed with the exhaust line and line, release and closure will be diametrically opposite up to 100 per cent release and closure. The difference comes from the fact that if we design for 85 per cent closure and 85 per cent release, with a line-and-line valve, and then add exhaust lap to get 95 per cent release, we shall, on the return of the piston, get a 75 per cent closure. This feature makes the Pilliod a design without limitations, as it could also be designed for 90 per cent line-and-line release and closure and, by adding lap for 95 per cent release, 85 per cent closure be obtained. This earlier closing feature is brought out to show that if the arrangement were applied to old power where the clearance space was extremely excessive, it would still be possible to get the long expansion, and


LEAD
2" Port
Dotted Lines show Baker with 1 1/4" Lap and 3/16" Exh Clearance
Full Lines show Walschaerts with 1" Lap and 0" Exh. Clearance
Dot and Dash Lines show Young with 1 5/16" Lap and 0" Exh Clearance
Pre-Admission
Opening Back
Closing Front
Opening Front
Closing Back
Pre-Exhaust
BAKER
WALSCHAERTS
YOUNG
0 1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 22 24 26 28
Stroke in Inches
Showing How Exhaust Opens and Closes

GEAR		LAP	CUT-OFF	EXPANSION	RELEASE	COMPRESSION	PRE-ADMISSION	OVER TRAVEL	VALVE TRAVEL
BAKER	FRONT	1 1/4"	73 5/16-85%	2 7/16-96%	26 1/2-94.6%	1 5/16-7.1%	0"		7"
BAKER	BACK	1 1/4"	73 5/16-85%	2 7/16-97%	26 3/16-92.8%	1 1/2-5.4%	0"	21/32"	7"
WALSCHAERTS	FRONT	1"	75 3/16-89%	1 5/16-69%	27 1/8-96.9%	1 1/16-4.7%	1/16"	22/64"	7"
WALSCHAERTS	BACK	1"	74 1/8-88.1%	2 3/16-91%	26 11/16-95.3%	7/8-3.1%	1/16"	44/64"	7"
YOUNG	FRONT	1 5/16"	75-89.3%	1 5/16-69%	26 5/16-96.7%	1 3/16-4.7%	1/16"	66/64"	8 1/2"
YOUNG	BACK	1 5/16"	74 1/16-86%	2 5/8-94%	26 11/16-95.3%	1 1/16-38%	1/32"	62/64"	8 1/2"

FIG. 3 COMPARISON OF FORWARD MOTIONS OF BAKER, WALSCHAERTS, AND YOUNG VALVE GEARS—FULL GEAR

still enough compression to avoid too much loss of live steam in the clearance space.

Lead and Preadmission. With the present-day design of the single-piston, variable-travel valve we must use excessive lead (the amount that the port is open at the beginning of the stroke) in order to get enough port opening in the shorter cut-offs. The lead, together with the lap travel, is obtained from the fixed travel on the lap-and-lead lever of the valve gear in the case of outside-connected valve gears, or from the advance of the eccentric in the case of the Stephenson gear. In the former case this travel is constant, as it is not changed when the reversing lever is hooked up in shortening the cut-off.

A condition prevailing in all outside constant-lead gears is that the lead is obtained at full gear with the minimum of preadmission, the latter being measured from the point where the valve starts to open before the piston has completed its stroke.

In the plain valve this preadmission varies in amount, depending on the point of cut-off. In the case of the Pilliod arrangement it will never be more than 1/16 in., and this amount will remain constant because of the constant travel of the plug and sleeve and the fact that the sleeve which is opening the lead is traveling much faster at this point than the piston. This means that the Pilliod arrangement will eliminate almost all of the preadmission, in addition to doing away with early closure, and thereby still further reduce the negative work. All of the force produced can then be applied to the crank, creating the drawbar pull which is the primary function of the locomotive.

Compression. Compression cannot be eliminated in the locomotive when existing valve gears are employed to operate the common variable-travel slide or piston valve. This fact has been made the subject of many an argument by textbook authors, and many of them have been led to reason out advantages that are presumably to be derived from its presence.

The losses caused by high compression are great and represent a large percentage of the excessive loss incurred in the utilization of the heat units in the steam engine. Professor Dwelshauvers-Dery of Liége, Belgium, states that as the compression is increased from 10 to 30 per cent, the increase in fuel consumption is 21 per cent; and that for a further rise of 40 per cent the amount of steam used increases 50 per cent. Part of this loss might be compensated for, it is true, in the decrease of the amount of live steam needed to fill the clearance space, but this saving would not be as great as some might think.

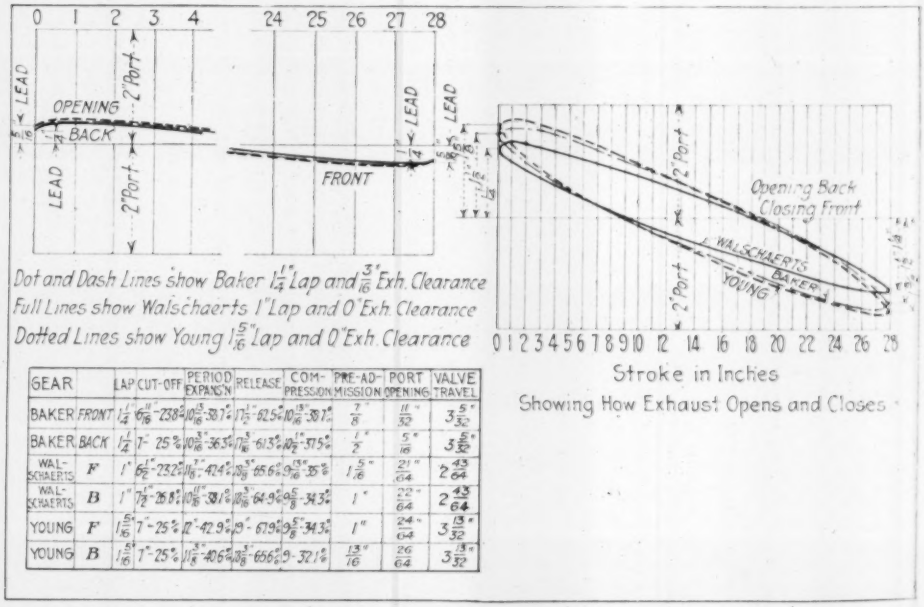
The author believes that from the point on the return of the stroke at which the piston commences to be retarded by the compression to the end of the return stroke, any compression of steam into the clearance space is a detriment.

Locomotive design at the present time is limited by the events that can be obtained from the combination of the plain plug and slide valve with the standard valve gears. At the working points of 25 per cent cut-off and 60 per cent release and with the exhaust line and line, the compression obtained is approximately 40 per cent.

The bad effects of this compression will be plainly seen when we consider that the engineer will have to drop the reverse lever down to a later point of cut-off if the throttle is closed and the engine is allowed to drift down grade while going at a high rate of speed. If the engine is kept set at a short working point of cut-off and the throttle is closed, the nosing action due to the heavy compression will nearly cause the engine to leave the track if the speed of the train is high enough. Many a main rod has broken under the stresses imposed by heavy compression, and it is not making too broad a statement to say that if the compression were reduced the life of the main rods would be much greater than it now is.

With the present-day valve events which are obtained with the plain piston or slide valve and the variable-travel variable-cut-off valve gear, compression is useful to a certain degree. If it were all eliminated the restriction of the admission port at the 25 per cent cut-off would be such that the clearance would not be filled with pressure steam by the time that the piston was ready to start back. This would mean a drooping steam line on the indicator card, and the loss in mean effective pressure would partly offset the added gain in the turning moment due to a complete elimination of the compression.

With the present-day valve designs, complete elimination of the compression would also increase the initial condensation of the steam as it enters the cylinder, in the plain saturated type

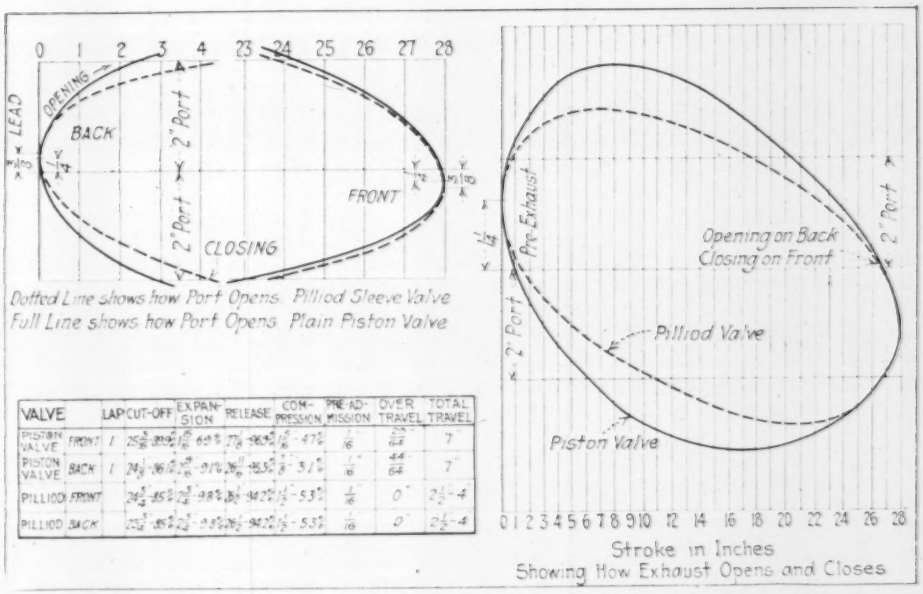

0 1 2 3 4 24 25 26 27 28
LEAD
2" Port
OPENING
BACK
FRONT
Dot and Dash Lines show Baker 1 1/4" Lap and 3/16" Exh. Clearance
Full Lines show Walschaerts 1" Lap and 0" Exh. Clearance
Dotted Lines show Young 1 5/16" Lap and 0" Exh. Clearance
Opening Back
Closing Front
WALSCHAERTS
BAKER
YOUNG
0 1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 22 24 26 28
Stroke in Inches
Showing How Exhaust Opens and Closes

GEAR		LAP	CUT-OFF	PERIOD EXPANSION	RELEASE	COMPRESSION	PRE-ADMISSION	PORT OPENING	VALVE TRAVEL
BAKER	FRONT	1 1/4"	6 11/16"-23.8%	10 5/8"-38.1%	17 1/2"-62.5%	10 5/8"-38.1%	7/8"	11/32"	3 5/32"
BAKER	BACK	1 1/4"	7"-25%	10 3/8"-36.5%	17 1/16"-61.3%	10 1/2"-37.5%	1/2"	5/16"	3 5/32"
WALSCHAERTS	F	1"	6 1/16"-23.2%	10 7/16"-47.4%	10 5/8"-65.6%	9 15/16"-35.%	1 5/16"	21/64"	2 43/64
WALSCHAERTS	B	1"	7 1/8"-26.8%	10 11/16"-38.1%	10 5/8"-64.9%	9 5/8"-34.3%	1"	22/64"	2 43/64
YOUNG	F	1 5/16"	7"-25%	10"-42.9%	10"-61.9%	9 5/8"-34.3%	1"	24/64"	3 13/32"
YOUNG	B	1 5/16"	7"-25%	11 1/8"-40.6%	10 5/8"-66.6%	9"-32.1%	13/16"	26/64"	3 13/32"

FIG. 4 COMPARISON OF FORWARD MOTIONS OF BAKER, WALSCHAERTS, AND YOUNG VALVE GEARS—25 PER CENT CUT-OFF

of engine. Initial condensation is increased to a certain degree by increasing the range of temperature in the cylinder. It also increases as the ratio of the area of the cylinder walls to the volume of the cylinder increases. Time is also an important factor and, other conditions being equal, the slower the speed of the engine, the greater the initial condensation. But reëvaporation is a deciding factor in the elimination of part of the initial condensation and is one element that must be considered in determining the amount of superheat that will show the greatest economy. In the plain variable-travel-valve engine now in use this initial condensation is increased by the wiredrawing of the steam at the point of admission (25 per cent cut-off) through the restricted port opening.

A factor that increases the negative work due to defects in the valve events is that of preadmission. Excessive preadmission, acting in the same manner as the excessive compression, tends to absorb the stored-up momentum in the engine that by right should go to the crank and be used as a turning moment.


0 1 2 3 4 23 24 25 26 27 28
OPENING
BACK
LEAD
2" Port
FRONT
CLOSING
Dotted Line shows how Port Opens. Pilliod Sleeve Valve
Full Line shows how Port Opens. Plain Piston Valve
Pre-Exhaust
Opening on Back
Closing on Front
Pilliod Valve
Piston Valve
0 1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 22 24 26 28
Stroke in Inches
Showing How Exhaust Opens and Closes

VALVE		LAP	CUT-OFF	EXPANSION	RELEASE	COMPRESSION	PRE-ADMISSION	OVER TRAVEL	TOTAL TRAVEL
PISTON VALVE	FRONT	1"	25%	39 1/2%	69 3/4%	77 1/8%	36 5/8%	47 1/2%	1/16	22/64"	7"
PISTON VALVE	BACK	1"	24 1/8"	36 1/2%	69 3/4%	91 1/2%	36 5/8%	35 3/8%	1/16	44/64"	7"
PILLIOD	FRONT		2 1/4"	45 1/2%	69 3/4%	98 1/2%	94 1/2%	53 1/2%	1/16	0"	2 1/2"-4"
PILLIOD	BACK		2 1/4"	45 1/2%	69 3/4%	98 1/2%	94 1/2%	53 1/2%	1/16	0"	2 1/2"-4"

FIG. 6 COMPARISON OF FORWARD MOTIONS OF PLAIN PISTON VALVE AND PILLIOD SLEEVE VALVE—FULL GEAR
(Walschaerts gear used in both cases.)

Summing up, the author feels that the compression due to early exhaust closure should never go beyond the point of a balanced ratio between the utilization of the energy stored in the moving parts of the engine and the cost of initially filling the clearance space with the live fluid; and that preadmission should be eliminated.

Curing the Effects and Neglecting the Cause. Trying to save part of the heat lost by reason of poor valve design seems to have been the best that has thus far been accomplished. We have the feedwater heater that endeavors to save at least a portion of the heat which otherwise would escape through the stack. Another remedial device is the brick arch. Brick arches do all that is claimed for them and they do save coal, but would they be able to effect the same percentage of saving on a compound that they can accomplish on the plain simple engine? It would hardly be possible. The saving of fuel by the arch is made possible through the fact that it prevents the unconsumed carbon from being drawn through the tubes by the heavy pull of the exhaust. We know that in the case of the compound with its increased number of expansions, the terminal temperature and the pressure of the exhaust are lower, with a resultant softer blast. The tendency of the exhaust to pull the fire is much reduced, even though the steaming efficiency of the nozzle is not impaired.

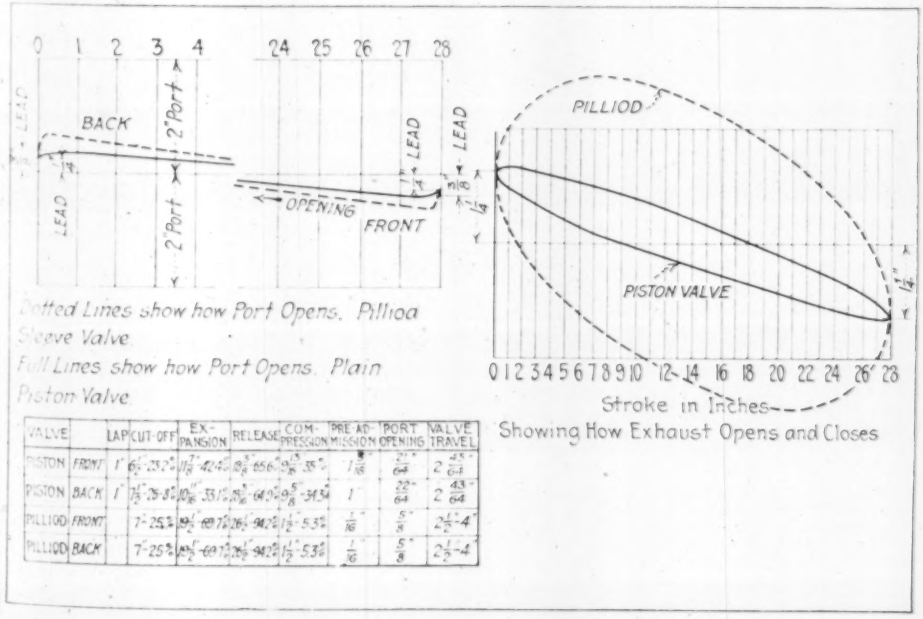
In reducing the terminal temperature of the exhaust the Pilliod sleeve-valve arrangement is a decided stride forward, as the proper utilization of the heat units is primarily a function of the valve in its permitting the piston to create turning moments on the crank, and the main function of the locomotive—that of production of drawbar pull—is thereby effectually increased.

The addition of arches and feedwater heaters to an engine equipped with the new sleeve-valve arrangement will result in further savings of heat units, although their respective efficiencies may not be as high as when these devices are applied to plain piston or slide-valve engines.

Superheating. A tendency to decrease the utilization of the heat units has been noticeable in later years with the advent of the superheater, even though its application to present equipment does show economy. We can assume that if superheat is employed only in the amount required to insure dry steam at the point of cut-off, we shall have accomplished all that is possible by its use, neglecting the value of its increased volume; this because the reëvaporation that will occur during the expansion period between the point of cut-off and the point of release will guarantee that we get dry steam throughout the entire range. This analysis would also seem to indicate that with increased expansion in any engine the effectiveness of superheating will decrease in direct ratio to the amount of expansion.

It is an accepted fact that the loss due to condensation on the cylinder wall diminishes with a rise in the initial temperature and pressure; the ratio of expansion remaining constant, this law holding without regard to the speed of the engine. Therefore the economy to be gained decreases with a rise in the pressure.

Advocates of a high degree of superheat have been presenting from time to time arguments showing that, due to the increased volume the steam receives when it is superheated, less steam is required per


0 1 2 3 4 24 25 26 27 28
BACK
2" Port
LEAD
OPENING
FRONT
PILLIOD
PISTON VALVE
Dotted Lines show how Port Opens. Pilliod Sleeve Valve
Full Lines show how Port Opens. Plain Piston Valve
0 1 2 3 4 5 6 7 8 9 10 12 14 16 18 20 22 24 26 28
Stroke in Inches
Showing How Exhaust Opens and Closes

VALVE		LAP	CUT-OFF	EXPANSION	RELEASE	COMPRESSION	PRE ADMISSION	PORT OPENING	VALVE TRAVEL
PISTON	FRONT	1"	25%	42 1/2%	69 3/4%	85 5/8%	35 3/8%	1/16"	22/64"	2 43/64"
PISTON	BACK	1"	25 5/8%	33 1/8%	69 3/4%	84 3/8%	34 5/8%	1"	22/64"	2 43/64"
PILLIOD	FRONT		2 1/4" 25%	45 1/2%	69 3/4%	94 1/2%	53 1/2%	1/16"	5/8"	2 1/2"-4"
PILLIOD	BACK		2 1/4" 25%	45 1/2%	69 3/4%	94 1/2%	53 1/2%	1/16"	5/8"	2 1/2"-4"

FIG. 5 COMPARISON OF FORWARD MOTIONS OF PLAIN PISTON VALVE AND PILLIOD SLEEVE VALVE—25 PER CENT CUT-OFF
(Walschaerts gear used in both cases.)

stroke of the engine. Is this a true condition of economy? Addition of heat in the form of superheat does expand the steam in the boiler, it is true. With 200 deg. superheat and with steam at 200 lb. boiler pressure we do get approximately a 32 per cent increase in the volume. But in so doing, it becomes necessary to use 15 per cent more fuel, and in addition the cost of maintenance is higher. However, the economy obtained on locomotives with the present old type of valve design and on other engines where expansion is not a large enough percentage of the total stroke, warrants its use.

It is the opinion of the author that a superheated engine equipped with the Pilliod valve arrangement could have its superheater removed, or at least have the degree of superheat lowered considerably, without affecting its coal consumption per ton-mile. This is due to the fact that the sleeve-valve-equipped engine gives at a very much shorter cut-off a mean effective pressure only possible on the conventional locomotive at a much longer cut-off. This last condition is true on a saturated engine, and much more so on a superheated engine.

Increased Expansion. A practical proof of the advantages to be derived from the use of the new valve arrangement can be seen when we compare its valve events with those of the Corliss engine. This engine is 30 per cent more economical than the standard automatic stationary engine, but is limited in the release, which cannot be made to occur past 85 or 90 per cent of the stroke, as the travel of the rocker arm would be too great. With the Pilliod arrangement, which gives any amount of expansion wanted, from any point of cut-off to the end of the stroke, even a better result should be obtained since no new or untried mechanical devices are involved. The addition of the extra moving sleeve will not cause a greater leakage, as the valve will not be subject to the wear that now takes place on the variable-travel valve. This matter of wear will be discussed in detail in the following paragraph.

Effect of Superheat on the Variable-Travel, Variable-Cut-off Valve—Elimination of This Defect in the Pilliod Constant-Travel Valve Arrangement. A defect not so noticeable in the days of saturated steam is that brought about by the action of the high temperature of the exhaust steam due to superheat on the exposed portions of the valve seat at the working points of cut-off. In time the seat will become scored and the rings plugged, resulting in excessive leakage of the steam past the valve. This leakage assumes very serious proportions at times. The Pilliod arrangement, in which the valves have constant fixed travels at all points of cut-off, will overcome this scoring, and the economy due to tight valves can thus be much longer maintained. The valve can also be operated longer without lubrication, due to the fixed travel and the elimination of much of the oil loss. It is also possible to liken the sleeve and the plug valve to a moving piston which is also traveling in a constant path at all times. The cylinder walls can never become carbonized or coked up, regardless of the degree of heat. In the case of the variable-travel piston valve, even without superheat the variable travel creates variable wear, and the leakage amounts to from 4 per cent to 20 per cent of the amount of steam used. Possibly the engine is not overhauled any oftener, but the loss remains, and a higher consumption of steam per hour can be the only result. In giving constant travel to the valve the new Pilliod arrangement thus eliminates one of the chief defects of the superheated engine and also makes possible a longer time between shoppings, even for saturated engines.

Setting the Valves. The plain variable-travel piston or slide valve presents difficult problems in setting, and to be able properly to square a valve gear one must deal with all of the detrimental angular influences that are present. In the case of the new sleeve-valve arrangement the matter is one of extreme simplicity. The design, as has been brought out, dissipates within itself all of the angular defects that have been heretofore considered as impossible of elimination.

Placing Limits on the Engineer. A big factor in the proper utilization of the available heat units would naturally be that the engine should never be run at any but the most economical point of cut-off. With the present variable-travel piston or slide valve and the conventional valve gear we know that the engineer can cause the cut-off to occur at a point too early in the stroke. The new sleeve-valve arrangement can be set at will in the shop for any point of minimum cut-off, and this minimum point cannot be changed by the engineer on the road. If it has been decided that the minimum point of cut-off should be 25 per cent, the cut-off-control bushing will be made so that it cannot be moved in past the point that will give 25 per cent cut-off.

Compounding. In the variable-travel valve as applied to the existing compound engines, steam is admitted to the high-pressure cylinder at, say, 25 per cent cut-off and exhausted into the receiver at around the conventional 60 per cent point of release. This means that there is more of a varying pressure in the receiver than if the steam were constantly released at the end of the stroke. Also, the high-pressure cylinder loses the chance to produce the additional work that is accomplished when the release is carried to the end of the stroke as in the Pilliod arrangement. When the conventional valve events are applied to the compound, there is also a loss due to the early exhaust closure in the high-pressure cylinder at the working points of cut-off. This back pressure means loss of steam, which would better be applied to the receiver for additional work than to oppose compression. In the Pilliod arrangement the steam as it is expanded to the end of the stroke is also all driven to the receiver on the exhaust stroke, as the valve does not close the exhaust until the piston has reached the end of its stroke and all of the exhaust steam has been passed into the receiver. This means a slightly higher consumption of steam, due to the amount required to fill the clearance, but the increased work performed will more than compensate for this, and a smaller steam consumption per horsepower-hour can be the only result.

Another condition prevailing in the compound is that of the ratio that must be maintained between the low-pressure and the high-pressure cylinders. This has never been accomplished in the compound, due to the fact that it has never been possible to get two sets of valve gears that could be linked to produce it at all points of cut-off.

In the new valve arrangement we are dealing with an auxiliary cut-off-controlling bushing which operates in a straight line and, as has been brought out, it effects at all times equidistant closing of the admission ports. The bushing is also controlled independently from the valve. From this it will be seen that it is only a matter of simple proportion to obtain any ratio that is desired between the two valve arrangements of the compound. Also, once these ratios are fixed, they cannot be changed but will always, through the entire period between shoppings, bear the same relations to each other that they had when new.

Continuous Torque Condition. With the present plain valve cutting off at 25 per cent and releasing and closing at 60 per cent, a very uneven torque is obtained. With the new valve arrangement it is possible to bring about a condition whereby at all points of the stroke the piston will receive some impulse and whereby none of the power thus generated will be dissipated in the negative work of compression and preadmission. The crank will therefore at all times have imparted to it a turning moment and the engine will be working in an extremely free condition. These strains now created by excessive unbalance will be eliminated, wear and tear will be greatly reduced and the lengths of the periods between shoppings increased.

CONCLUSION

In what has gone before the author has endeavored to show that by employing a combination of time-tried devices for controlling fluid events, Mr. Pilliod has made it possible to effect in the locomotive a steam distribution superior to that obtained in the Corliss stationary engine, and in addition has made it impossible for the engineer to cause the cut-off to occur earlier than at its now considered most economical running position. While some, no doubt, will disagree with certain of the conclusions arrived at, it is nevertheless believed that the analysis from which they are drawn is logical; and if the paper shall prove of service in stimulating thought on the subject, he will feel that the work required for its preparation has not been wasted, but has been well worth the effort.

Machining and Lapping Very Deep Holes

By MAJ. JOHN B. ROSE,[1] FORT LEAVENWORTH, KAN.

The purpose of this paper is to give in as much detail as practicable at this time a discussion of the shop operations in the forming of very accurate and highly finished cylindrical holes. Work of this kind carried on during the war in the manufacture of recuperators for gun carriages led to very extensive study and experiment, and the processes followed are believed to possess many points of interest to engineers. The drilling, boring, reaming and lapping operations are discussed in order, especial emphasis being laid on the lapping as this was the operation which gave the greatest difficulty and was most closely studied.

DURING the period of our war activities it is probable that no one manufacturing process called for the expenditure of more thought and skill by engineers and machinists than the production of the long and very accurately formed cylindrical holes in the forgings from which gun-recoil mechanisms were made.

These cylinders or long holes varied in size from 1.575 in. to 7.875 in. in diameter and from 5 to 8 ft. in length. To insure good performance it was required that the several cylinders have unusual accuracy of form, size, and position. While extreme accuracy of relative position was not demanded, it was largely obtained as a result of the care necessary to secure accuracy of the first two kinds.

It is believed the operations in producing these cylinders are without precedent in the United States, and certainly not on any scale of like magnitude. For this reason it is felt a record of certain of the machine set-ups and details of the processes should be of interest to shop engineers. It has very frequently occurred that devices or processes which were originally military in nature have found a more useful application in the arts of industry.

Mr. A. L. De Leeuw, Mem. Am.Soc.M.E., has contributed a series of articles to the *American Machinist*,[2] which very ably discuss the manufacturing operations carried on at the Singer Manufacturing Company, including the series of operations in the manufacture of the complete recuperator body. His articles should be read to obtain a comprehensive view where this is desired, and for a comparison of methods. It is here proposed to limit the discussion to the drilling, boring, reaming, lapping, and polishing of the holes.

Even with this restriction it will not be practicable to cover within suitable limits more than one job which will illustrate production of the cylinders up to 2.6 in. in diameter.

It is proposed to discuss these operations not in their connection with the building of a mechanism but in their relation to the pure art of such operations wherever they may be used. This paper then will avoid any technical discussion of recuperators or the history of their war production. It will record only the shop operations and to the extent that these may be of general industrial interest.

The problem is to produce approximately parallel holes 5 to 6 ft. long in a steel forging; the holes to be straight and round to a high degree of accuracy, free from visible scratches, and with a mirror-like finish.

Drilling

Figs. 1 and 2 show the shape of the forging ready for drilling the small hole (1.338 in. diameter and 63 in. long). The drill leaves the hole 0.236 in. under the final size. The average time for set-ups and through drilling was three hours.

The surfaces *A* and *B* (Fig. 2) were milled and on these the forging rested in the fixture shown in Fig. 3. This fixture was made to insure correct centering of the drill and is mounted rigidly on the carriage of a 25-in. heavy-duty LeBlond lathe. The bearing or guiding surfaces of the fixture were ground to correct location after trial on the lathe with which it was used.

Incorrect drilling was caused at first by the method of securing the piece. By means of two bolts attached to the tail end of the fixture and pulling on the piece, the latter was pressed so hard against the drill guide as to force it out of line and the drill ran at an angle. This was easily overcome by holding the piece against the drill guide by two bolts attached to the latter itself. The original error is obvious and should, of course, never have been made.

On account of depth of the hole the drill was run in half-way, and the piece then reversed either on the same or on a second machine. Good results were obtained by both methods.

It is very desirable that the drilled holes meet. If they do not, the accuracy of each following operation, even to the lapping, is affected, since each tool naturally tends to follow the hole it is enlarging. The correction of inaccurate drilling will be dealt with

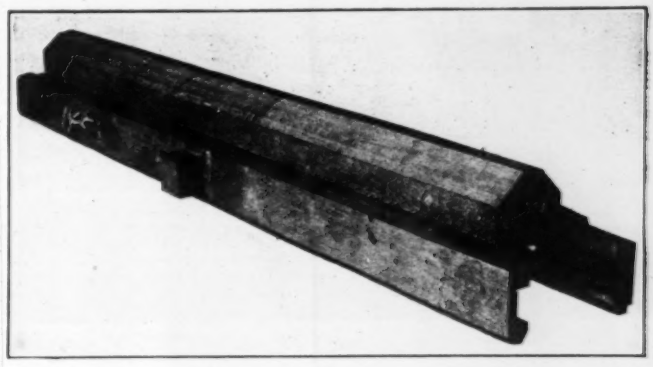


Fig. 1 Forging Ready for Drilling Small Hole

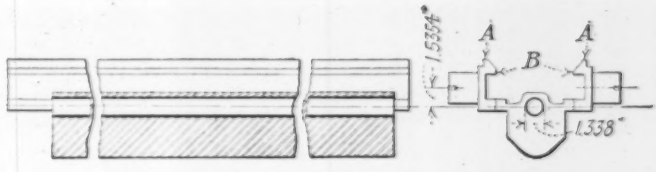


Fig. 2 Longitudinal Section and End Elevation of Forging

when considering later operations. In approximately 33 per cent of all drilling the drills did not meet accurately, the maximum variation being $^1/_{16}$ in.

To secure speed it is necessary to provide efficient cooling and prompt removal of chips. Figs. 4, 5 and 6 show the hollow-shank drills used for this purpose.

A mixture of 1 qt. of soluble oil with 3 gal. of water was boiled for half an hour and about a pint of sal soda added. This solution was forced under about 70 lb. pressure into the hole through the drill shank, along the oil clearance, over the end of drill and back through the flutes and hollow shank. Chips were reduced to narrow strips by cutting grooves $^1/_{16}$ in. by $^1/_{32}$ in. as shown at *N*, Fig. 4. The chips pass out with the oil through the hollow drill tube. In the earlier efforts the chips were not expelled satisfactorily, and it is probable that one of the principal causes of this was insufficient pump pressure. It was not practicable to increase the pump capacity and the remedy was effected by forcing air in with the oil. The small pipe in Fig. 3 carries the air at a pressure of 90 lb. This greatly improved expulsion of the chips and permitted continuous drilling. It is also necessary that the grooves in the drill be sharp-cornered and the passages leading to the interior or drill have polished round corners to avoid congestion of chips.

Figs. 5 and 6 show the characteristics of the drills used. In addition to features already noted, it was found very necessary to taper the drill 0.004 in. on a side. Some of the earlier drills used were not tapered and frequently broke due to seizing in the hole,

[1] U. S. Army. Mem. Am.Soc.M.E.

[2] Vol. 52 (1920), pp. 595, 937, 1049 and 1094.

Contributed by the Ordnance Division for presentation at the Annual Meeting, New York, December 4 to 7, 1922, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. Abridged. All papers are subject to revision.

The life of the drill depended largely on the forgings. The quality of these varied greatly, as shown by Brinell tests. In some cases a drill might finish three holes before regrinding, while again it would go only a few inches. With forgings of uniform proper machinability one drill should complete a hundred or more holes in its life.

It may be noted that the method of drilling used by the Singer Manufacturing Company was quite different from the Rock Island method described. At this Company's shops the forging was mounted in a revolving steady rest and the drill run in a counter direction. No air was used. The drill itself was similar but 0.021 in. larger. It was run in half-way and then the entire fixture and forging reversed as a unit. In drilling the large hole

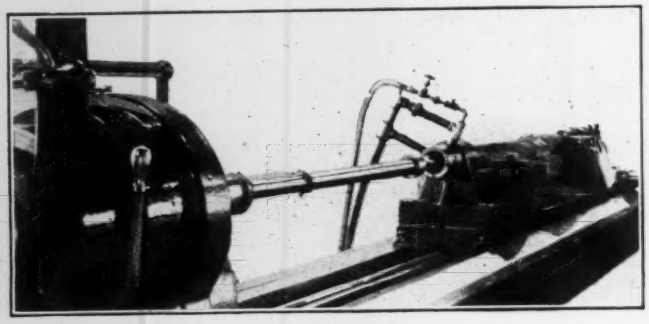


FIG. 3 FORGING MOUNTED IN LATHE FOR ROUGH-DRILLING OPERATION

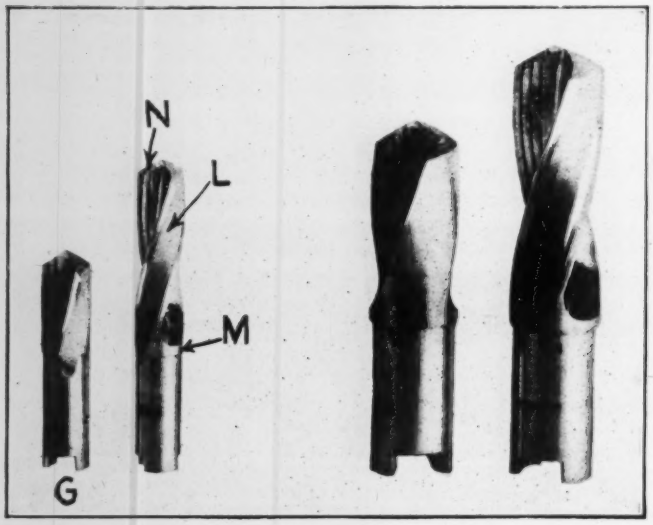


FIG. 4 HOLLOW-SHANK DRILLS USED IN DRILLING OPERATION

next described, Singer held the drill stationary. It was desired to rotate the drill also, but delivery of suitable machines was delayed.

In drilling the large hole, all features of the operation were essentially identical with those in drilling the small hole, except that the hole being off the axis of the forging, the latter could not be reversed in the same fixture, but went to the next machine. The drill for this operation is shown in Figs. 4 and 6, the characteristics of operation being as follows:

	Small hole	Large hole
Drill size, in	1.338	2.362
Speed, r.p.m.	248	70
Feed per revolution, in.	0.0016	0.008

Speed and feed were varied to suit the character of the forging, those here given being among those generally used.

While probably a little more power is required when work is rotated, this method holds the axis of hole true, even though the hole itself may be conical.

BORING

Fig. 7 shows the forging ready for the boring operation in holes after drilling, and also cross-sections at subsequent stages. In the shop this was sometimes called "roughing-reaming." The most important feature of this operation is to get the hole as nearly straight as practicable. When the drills have not met exactly or within a few hundreths this is difficult to do, especially in the small hole, for which the bar is but 1 in. in diameter and not stiff enough to keep the cutter running true.

The forging was held in a fixture very much like that used for drilling and secured to the carriage of the lathe, but the cutting tool was drawn instead of being pushed. The set-up for the large hole is shown in Fig. 8, the view being from the head end and the forging not in position. The double-end fly cutter is guided into the hole by the follower shown half-way out of the guide of the fixture. This follower does not leave the guide until its end next to the cutter has passed into the hole and is able to force the cutter to cut very nearly along the true axis. The outer sleeve on the follower is free to turn and is hardened and has a diameter across the lands 0.0008 in. less than that of the cutter. It was found that in spite of this follower, one roughing cutter would not true up the small hole very well when the drills did not meet. This led to the use of a leading cutter 1.375 in. in diameter and placed at right angles to the second cutter, and a better hole resulted.

Figs. 9 and 10 show the bars, cutters, and followers respectively used in the small and large holes. The boring leaves the large hole 0.118 in. below final size, and the small hole 0.123 in. Mineral lard oil was forced through from the head end and carried the chips out through the grooves in the follower. In early efforts a cast-steel follower shown in Fig. 8 was used which had a series of hardened studs ground to the size of the hole, but this type of follower was soon discarded as it did not hold its size so well as the one with longitudinal ribs.

At first a reamer cutter was used of the form also shown in Fig. 8, this being a foreign type. It did not work so well due to the breaking down of the outer point on the cutting edge which led to seizing in the hole, as the original tool did not have proper relief back of the cutting edge. The preference abroad for this cutter is most probably due to the softer steel used.

	First Bore	
	Small hole	Large hole
Size, in.	(2 cutters) 1.375, 1.456	2.48
Stock removed on diameter, in.	0.037, 0.081	0.118
Average time of operation, including set-up, hours.	2	2
Feed per rev., in.	0.015	0.015
Speed, r.p.m.	60	60

At the end of the boring operations the holes are neither straight nor parallel. It will be noted that so far the piece has been set in two fixtures for drilling each hole and in one fixture for boring each hole, a total of six fixtures. The relation of the guiding surfaces of these fixtures to the center of the drill rest and lathe spindle was made correct to about 0.001 in. for each machine by special fitting, but the clearance of the drill tube in the guide and deflection in working, plus the summation of machine differences, may easily amount to several thousandths of an inch; or the errors may compensate, leaving a smaller resultant error.

It is permissible to admit these errors in position up to this point. Their total will seldom exceed 0.05 in. and is ordinarily very much less. As will be shown, the reaming fixture is designed to correct or improve parallelism and straightness.

It is well to note here that after the set-up has been made on the

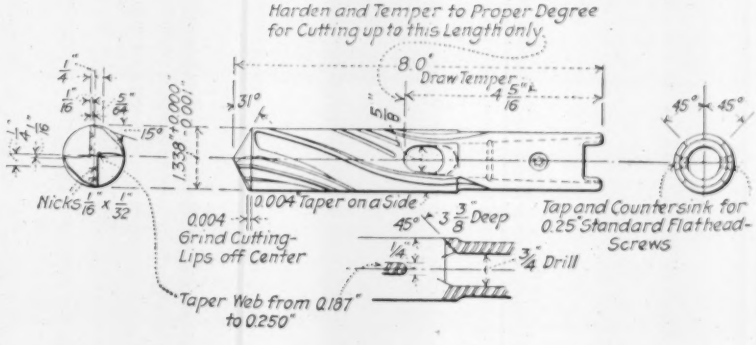


FIG. 5 DETAILS OF 1.338-IN. HOLLOW-SHANK HIGH-SPEED STEEL DRILL

machine for reaming about to be described, a second boring cut is made in each hole. For this 1.540-in. and 2.560-in. fly cutters are used, these removing respectively 0.074 in. and 0.08 in. of stock on the diameter. These cuts may be considered as either finish boring or rough reaming. They are not considered in the discussion of reaming below.

REAMING

Reaming is the first operation that approaches precision, and the quality of the reaming affects very much the accuracy of lapping. After the rough-boring the piece is planed or milled practically all over; the surfaces being measured from the center of the bored small hole. After reaming both holes, these surfaces are for the most part finish-planed or milled, being again located from the center of small hole. In the reaming it is not necessary that the holes be located with extreme accuracy with respect to the planed surfaces as enough stock is left on these to finish up, but the reamer should leave the holes parallel, round, straight, and smooth.

Fig. 11 shows the set-up for reaming the large hole. The small hole has been finish-reamed and the piece is now trued up on centering plugs which are expanded to fit snugly in each end of the small hole. The piece is supported and held in the fixture below it, which has adjustable bearing surfaces so that the plugs merely align the work but carry no weight. The axis of the bushing in the steady rest for the reamer, and the lathe spindle must be correctly and accurately located with respect to the center line of the two plugs. In reaming the small hole the set-up is identical with that described for the large hole, the centering plugs being adjusted to fit in the bored large hole. It is evident, therefore, that the exact relative positions of the holes and their degree of parallelism must depend on the parallelism of the reamer bar with respect to the center lines of both sets of plugs. The piece being aligned on the plugs parallel to the reamer bar, the reamer is constrained by the packed head to cut on its proper axis, but not entirely so, since after the head leaves the guide it is not controlled except by the hole itself.

Two or more cuts are taken with wood-packed reamers of the kind shown in Figs. 12 and 13. The greatest care was taken with this reamer to see that it left a smooth finish free of all but the finest scratches. If defects were found in the steel, as frequently occurred, or if the reamer left scratches, one or more oversize reamers were passed. The first packed reamer leaves the large hole 2.584 in. or 0.018 in. under size, and the second or finish reamer cuts from 2.595 in. to 2.599 in. or 0.005 in. to 0.001 in. under the nominal maximum. In actual practice the character of steel in the forgings varied so greatly that it was found necessary to allow several oversizes, as this permitted rereaming to remove defects.

The importance of a uniform and clean steel cannot be overemphasized where it is necessary to produce all holes to the same size. Lapping, as practiced, did not straighten a crooked hole except to the extent later indicated, and as it is also a very slow operation it is highly important that the hole come from the reamer true and smooth. If it is not true it can only be partly straightened under the lap, and if scratched or rough more metal must be left for lapping or it must be lapped oversize.

In Fig. 11 the packed reamer head is seen leaving the guide and the cutter has not yet entered the hole. The plug is shown at *A* not fully entered into the small hole. The piece has been moved about 2 in. toward the lathe headstock in order to show these parts. In operation it is forced to the rear until the bushing of the guide, which has a lead-packed end, is in contact with the rear end of the piece and closes the hole, thus forming the oil channel. Pure lard oil is fed through the pipe at *B* and passes through the bushing thence into and through the hole and out the front end around the tool.

	Small hole		Large hole	
	Rough	Finish	Rough	Finish
Size, in.	1.56	1.575	2.584	2.599
Feed per rev., in.	0.025	0.025	0.025	0.025
Speed, ft. per min.	30–40	30–40	30–40	30–40
Stock removed, in.	0.02	0.015	0.024	0.015
Oil used	pure lard	pure lard	pure lard	pure lard

The wood-packed reamers were kept soaked in pure lard oil. The packing was turned to 0.002 in. above diameter of the cutter. The guides in the steady rest were hardened and ground to 0.001 in. above the diameter of the steel followers and were a snug fit over the packed reamer heads. Fig. 14 shows some of the more detailed characteristics of one of the reamer blades.

Attention has already been called to the importance of good reaming. It is necessary to select a steel for the reamer which holds its edge and does not chip off, as this may destroy a hole.

The blades must be ground with clearance and rake on the cutting edge, which are determined by experiment on the work, and the angles first given on the tool drawings may be used only as a

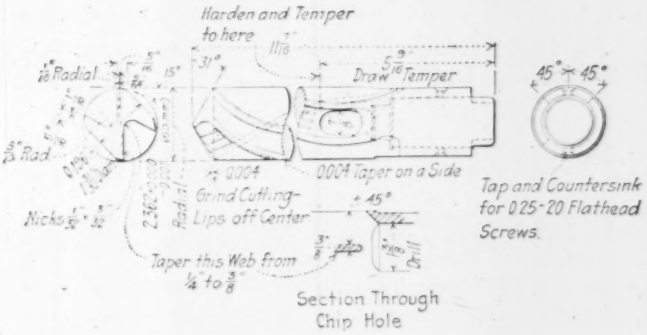

Harden and Temper to here
Draw Temper
45° × 45°
Radial
.004 Taper on a Side
Grind Cutting-Lips off Center
Tap and Countersink for 0.25-20 Flathead Screws.
Taper this Web from 1/4" to 3/8"
Section Through Chip Hole

FIG. 6 DETAILS OF 2.362-IN. HOLLOW-SHANK HIGH-SPEED STEEL DRILL

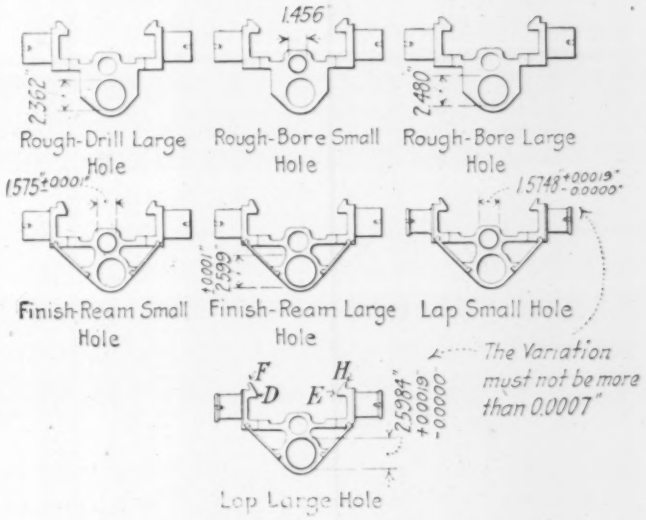


FIG. 7 BORING AND SUBSEQUENT OPERATIONS ON FORGING

preliminary guide. It was the practice to have one man specialize on grinding the blades and it cannot be said the practice was standardized. The cutting edge was usually given a taper of 30 deg., but this angle was varied to suit depth of cut or hardness of steel.

An experienced man can usually tell by holding his hand on the reamer bar whether the tool is cutting well, and chips should be smooth and well formed. If these indicate the cutting edge has broken down it must be immediately reground, and the cutting edge at the beginning of the taper carefully stoned.

Reaming should be continuous since a mark is invariably left after stopping, due to contraction of wood or other parts or substitution of a new reamer. The reamer must never be drawn out while the machine is running as this leaves a spiral line. The reamer blades should be set by a specialist, who also sees to correct grinding and to oil stoning after grinding.

Slag pockets are serious for several reasons: they may be too deep to remove, or they may destroy the finish by breaking down the cutting edge and cause scratches.

At the Singer Company's shops the large and small holes were bored and reamed in two settings of the work, one for each hole. For work on the small hole the piece was set in a fixture mounted on a 24-in. heavy-duty Pond lathe in somewhat the manner of the Rock Island method, and the boring and reaming tools drawn through in succession. They were guided at the beginning of the

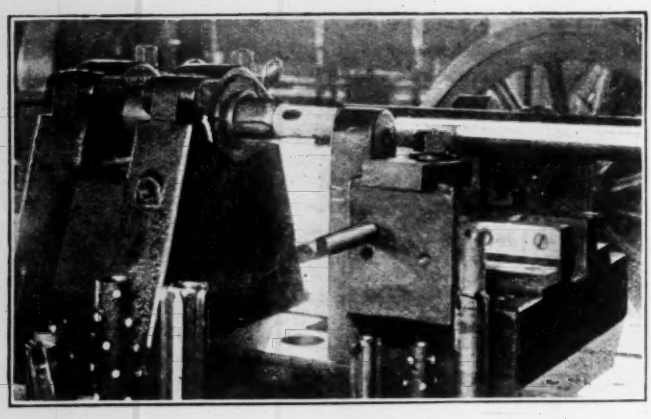


Fig. 8 Fixture for Rough-Reaming Operation

cut in a manner also similar. These features, however, were different: (*a*) No fly cutters were used, but the boring or rough-reaming was done with a reamer which required oil flow in a reverse direction. This is the type of reamer above referred to as having been discarded by the arsenal, but it is here used with success. (*b*) The holes were finish-reamed in two fixtures and the relative location of the holes with respect to each other would not seem to be so well controlled as by the Rock Island method, which mounts the piece on the locating plugs in the same fixture, but there are no data available to show whether this is true.

At the Singer Company's shops the large hole was bored and

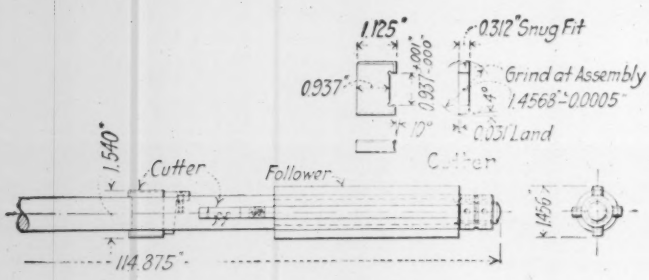


Fig. 9 Bar, Cutter, and Follower for the Small Hole

reamed in a revolving fixture like that used for drilling. It was proposed to do this drilling in the same manner as for the small hole, but fixtures were never completed.

Lapping

A proper appreciation of the art of producing these holes with mirror-like surface cannot be obtained without some consideration of the steel characteristics. The ordinary run of steel, such, for example, as S.A.E. No. 1035, will, after rough-machining and reduction to a cross-section suitable to take treatment, take a fine finish in a bored hole from reamer, broach, or grinding wheel. Whether it can be lapped and polished free from scratches is altogether another matter, as this depends upon its condition.

If a mirror-like finish free from scratches is required at the end, it is clear we have a different problem. The utmost cleanness and homogeneity is necessary. Slag inclusions or oxides will show up in the final operations and the entire work be lost. Machinability must be good, as a small tear may be disastrous.

The first problem thus appears in the selection of the steel. Ordnance gun steel is clean and quite machinable, but unless very carefully made it is not clean enough to give a mirror finish in lapping. It is probable that our steel makers during the war were somewhat skeptical as to the necessity of delivering a perfectly clean, soft steel. We know, however, that excellent and satisfactory steel can be produced by American processes when the requirements are understood and fully accepted.

Since for the lapping operation clean steel is fundamental, it is necessary to go into this at more length. Slag and other impurities are practically independent of the chemical composition of steels which may be employed, and the amount of inclusions will depend upon furnace and pit practice. It is not so much a question of the kind of steel as it is of the care in manufacture. The electric furnace undoubtedly gives a very superior clean steel, but this is due largely to proper care and it cannot be concluded that the open hearth will not yield a steel equally clean. In fact, we know it can, and it remains for the steel buyer to decide which process is more likely to give him a steel free from inclusions. If the steel makers understand the requirements, either kind can meet them if the necessary precautions are taken, but in the open hearth greater care must be exercised and the electric furnace is probably surer.

Both the Watertown and Rock Island Arsenals have had extended experience in lapping, and have each reached definite conclusions. The Rock Island Arsenal favors a nickel alloy steel made in the electric furnace, and very excellent results have been obtained with a steel of the following percentage composition:

Carbon	0.30 to 0.40
Manganese	0.50 to 0.80
Sulphur	less than 0.045
Phosphorus	less than 0.040
Silicon	0.15 to 0.35
Nickel	3.25 to 3.75

The steel to be free from all slag inclusions, flakes or any lack of homogeneity, and heat-treated to give elastic limit of 65,000 lb. per sq. in. It was found that this steel worked freely under the stone and took a high polish without the appearance of scratches or pockets due to soft spots.

It may be noted here that the initial cost of the steel must not be given too much weight, for unsuitable steel is in the end very expensive, due to eventual rejections. Such rejections were a

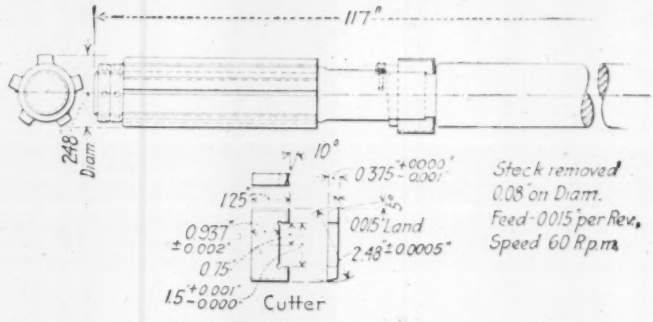


Fig. 10 Bar, Cutter, and Follower for the Large Hole

serious burden in our war manufacture. Too often we blamed the laps for scratches, when in reality the steel itself was the source of trouble, or the entrance of foreign particles of dust and steel.

The Watertown Arsenal feels that the acid open hearth will give steel as free from inclusions as the electric furnace with careful control of melting practice and proper top and bottom discard.

It is not possible in the limits of this paper to discuss all sides of the steel question, nor is it desirable. But we can draw a few conclusions from our experience to date. To secure the best results we are fairly sure that:

a The steel must be produced by the most careful furnace and pit practice

b It must be thoroughly deoxidized, free from slag and inclusions which produce scratches or pit marks in lapping

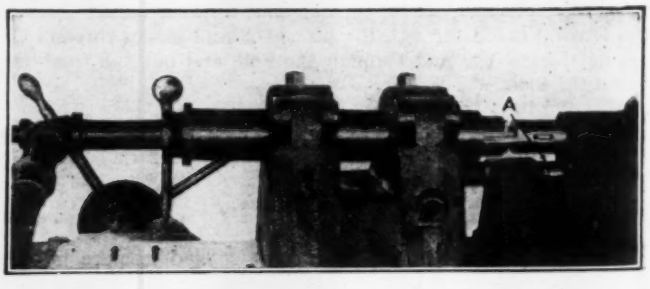


Fig. 11 Set-Up for Finish-Reaming the Large Hole

c The chemical composition may be such as to yield physical qualities desired under the heat treatment permissible

d The heat treatment must be such as to produce great uniformity in hardness and the desired physical properties.

A few words regarding heat treatment are necessary. In dealing with forgings of large cross-section it is evident that the desired qualities can best be secured after rough-machining and boring. During the war it was necessary to heat-treat before rough-machining, due to the lack of machine shops, with heat-treating facilities suitably located or available, to conditions of transportation, distribution of work, and various other influences. Basically it is much better to heat after reduction of the forging to nearly its final shape.

After finish-reaming, finish-planing and milling certain surfaces, the piece goes to the lapping machine. It is not desired to present this machine as ideal; in fact, it has numerous defects. First of all, horizontal lapping of cylinders is believed to be fundamentally wrong, since the gravity forces are constantly changing, as will be shown. In addition, the machines used were noisy and the reciprocating weights unnecessarily large. It can only be said that vertical lapping required too much head room to permit it, and that these machines were the best obtainable at the time.

Fig. 15 shows the machine rigged for lapping. The piece is held stationary in its fixture and the upper bar with the lap is reciprocated by means of the traveling carriage as in a shaper. The lap cuts on both strokes and is rotated 30 deg. at each reversal. As the stone is about 60 deg. wide it overlaps the preceding stroke

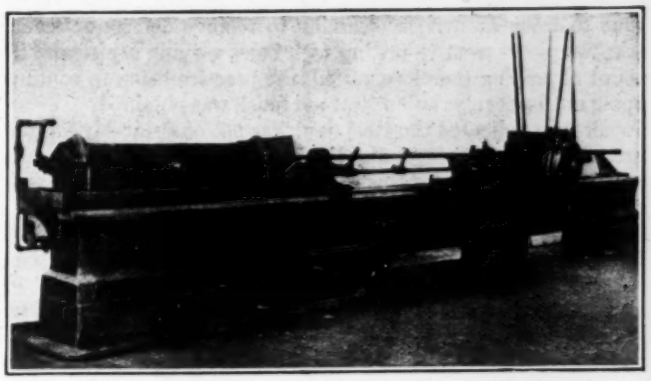


FIG. 15 ROCK ISLAND ARSENAL TYPE LAPPING MACHINE

the accuracy and finish of the reamed hole; hence it is obvious that the more accurate the reaming and the better the finish, the less there will be to lap. Working in good steel, 0.004 in. on diameter is enough to allow removal of reamer marks and leave a polished finish, but ordinarily more than this was left for lapping.

Figs. 16 and 17 show details of the lapping heads and stones used. (In the figures wood lap blocks are shown.) It was originally intended that the stones should be forced out by radial coiled springs, thus securing a uniform pressure in the hole, but this was abandoned for the reason that a uniform pressure does not lap the hole

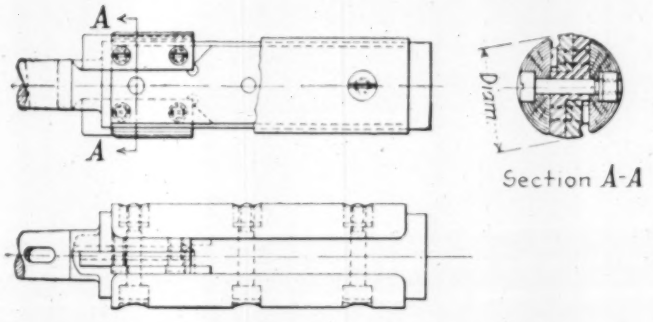


FIG. 12 WOOD-PACKED REAMER USED IN LARGE HOLE

(Ground to 2.584 in. diam. for rough-ream; to 2.599 in. for finish-ream; to 2.610 in. for 1st oversize. Tolerance ± 0.0005 in.)

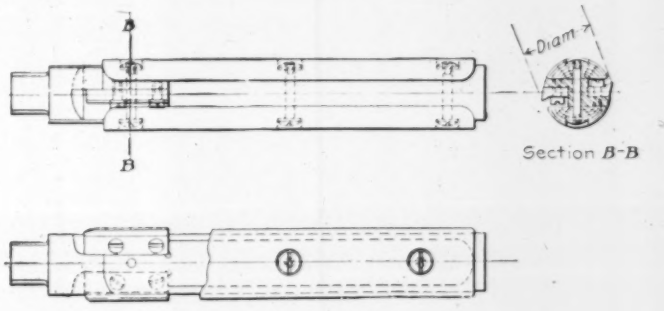


FIG. 13 WOOD-PACKED REAMER FOR SMALL HOLE

(Ground to 1.56 in diam. for rough-ream; to 1.575 in. for finish-ream; and to 1.585 in., 1.595 in. and 1.605 in. for 1st, 2d and 3d oversize ream. Tolerance, ± 0.0005 in.)

and no lines are left. The stroke is adjustable in length and the carriage may be set to lap any section of the hole desired.

The piece is slid on the fixture, the edges *D* and *E*, Fig. 7, resting against the vertical guiding surfaces of the fixture, and the surfaces *F* and *H* supporting the weight and fixing the holes in proper vertical relation to the center line of the lap bar.

There is a clearance of about 0.01 in. between the guides of the work and the vertical sides of the fixture, so it is manifest the hole is not aligned very accurately with the center line of the lap bar.

It is evident that the hole thus partly guides the lap. In view of the inevitable flexing of the long bar it is of no use to set up the piece with rigid accuracy, and the lap is therefore allowed to float with comparative freedom in the hole, the more so the better.

We must therefore say that the object of lapping is to improve

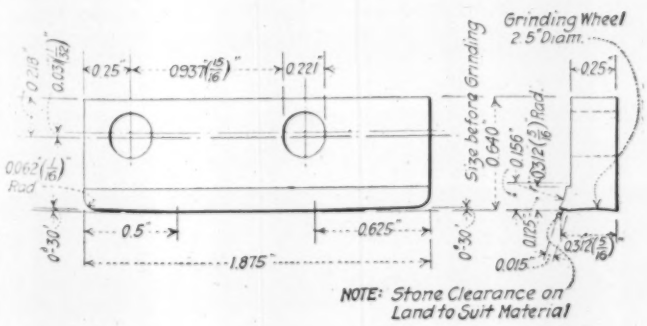


FIG. 14 DETAILS OF FINISH-REAMER BLADE

uniformly when the sections are of unequal hardness, and if there are small and large sections these remain respectively small and large. The stones were therefore assembled in the head and shims placed under them until they entered the hole snugly. Shims were also added as the stones wore down. By this method the pressure is least on low spots, or if a spot is soft and wears faster, the pressure is automatically reduced. It was proposed to use heads with a taper adjustment, but these were never actually employed.

After finish-reaming the holes were star-gaged to 0.0001 in. and this record went to the lapping machine. By experience it was determined that in a certain time the stones would remove a given amount of material, and it was possible for the gang boss to examine the record of gaging and direct so many minutes' lapping on each piece, based on the amount of metal to be removed. A general rule was not altogether reliable for the final stages of lapping as there was not sufficient uniformity in the steel or in pressure of stones; and it was customary for the gang boss to determine the lapping constant for each piece after a preliminary lapping of about 20 minutes and star gaging. This constant was then used to set the times required for further lapping required.

It was seldom possible to obtain a round hole with a variation in size of less than 0.0005 in. without resorting to spot lapping. Means were provided for frequent star gaging upon call of the gang boss, and if the record showed small or large sections the stroke was adjusted by the gang boss to spot-lap the small diameter. In this way the total variation measured on diameters would be made 0.0005 in. or less. Ordinarily this required about eight hours or more per piece.

Due to frequent oversize reaming to remove defects or reamer marks the pieces went to the lap with holes varying in size and the amount of lapping therefore varied, the practice being to continue lapping until a regular hole with good finish was obtained.

As already indicated the steel used was not of a suitably uniform character to permit a standardized shop practice with resulting economy in time, and for this reason the question of steel has been emphasized.

The important characteristic of the holes was roundness and this was obtained. They were not accurately straight in the sense of a straight edge. Accurate records have unfortunately not been taken on enough finished recuperators to permit a statement of the variation in straightness. Isolated measurements indicate some of the holes may have been bowed as much as 0.035 in. These were very bad ones and very unusual. An average good hole was straight within an error of 0.005 in. Of course this is far from straight in comparison with a straight edge, but for a small hole 5 ft. long the

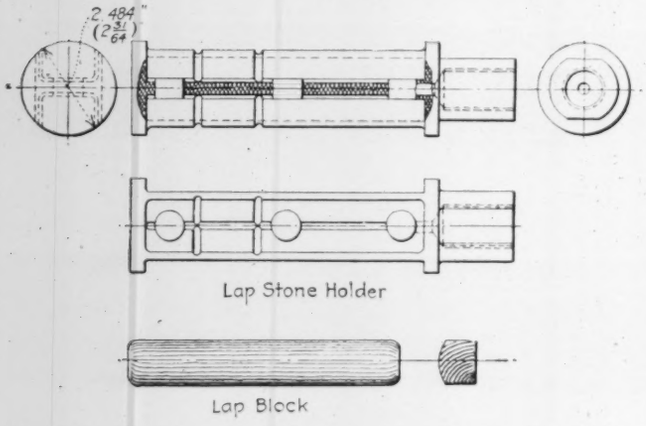


FIG. 16 DETAILS OF LAPPING HEAD AND STONE USED FOR LARGE HOLE

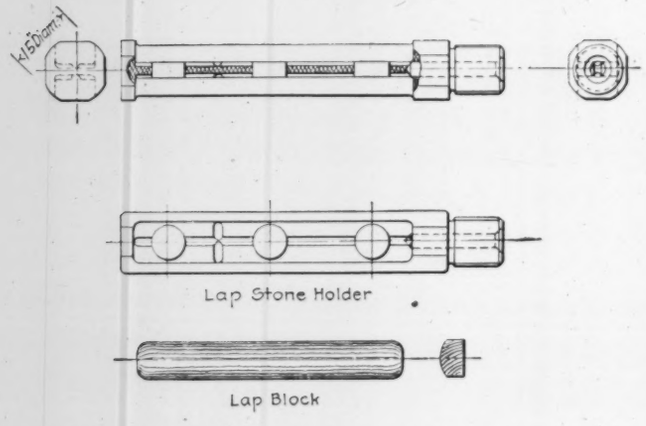


FIG. 17 DETAILS OF LAPPING HEAD AND STONE USED FOR SMALL HOLE

accuracy is good for quantity production and it probably can be improved under standardized conditions.

The lapping head of type shown gave acceptable results but it is felt that it can be improved. Four stones instead of two might give better results. The method of adjusting the stone is slow. There should be a quick adjustment to suit the hole. In the end additional vent holes were drilled in the head to allow more free access of oil to the stones.

A mixture of one-half kerosene and one-half pure lard oil was run to the lap through the hollow lap bar. An increase in the amount of kerosene gave greater cutting speed when desired. It is essential to circulate the oil through a filter and keep it very clean.

It is evident that as the lap passes through the hole the pressure on the top and bottom varies as the overhung weight of the lap and bar varies. This actually tended to cause a variation in the size of the hole, but was corrected when necessary by spot-lapping. A nicely reamed hole requiring little lapping could be finished quickly before these variations would appear, but if poorly reamed the lap would in extended use produce variations in diameter. Also in extended lapping there is a tendency to wear spots unequally, due to a difference in hardness. In other words, the lap does not straighten the hole except when spot-lapping is resorted to, and this should not be necessary; therefore the steel must be uniform and good reaming insisted upon.

The pressure on the top and bottom is not the same nor is it the same as on the sides. It may seem that this would produce an elliptical hole, but it does not due to the fact that the diameter across the stones is enlarged by shims as the hole wears and the small diameter of the hole gets the most cutting each time this is done. The effect of this pressure due to weight is, however, to lower the center line of the entire hole, and it is also true that if the center line of the reamed hole is not lined up with the lap stroke, the axis of the hole will be shifted. This again emphasizes the importance of minimum lapping. The lapping speed was about 275 ft. per min. The machine had a lower speed, but this was seldom used.

LAPPING STONES

The selection of suitable stones led to many weeks of experiment before the proper grain and grade could be determined. Abrasive stones of all the leading types were tried, with many peculiar results. As a very fine finish was sought, it may seem that the finest grain would be suitable. This was not true. A stone of grain 220 (the finest above the flour) would, for example, not give a finish, but in certain cases would stop cutting and burnish a streak.

Carborundum 180G4 was found the best cutting stone in nearly all cases. This stone cut clean and smooth, and in many cases the finish lap or polish was given with it alone. Again, one stone would be replaced by a hard-maple block and the combination gave a fine polish.

A gang boss was in charge of each six machines and this man learned by experience, from the appearance of the hole, which combination would most likely give the best finish.

When 180G4 would not finish, a FFG4 was used either alone or in combination with a maple block. The two maple blocks were never used together as the tendency was to burnish in streaks and cutting action was necessary up to the end.

It is necessary to keep the stones ground flat on the under side which lies against the shim, and to the correct radius on the curve. This was done by rubbing them on cast-iron lapping blocks, flat or ground to radius, with kerosene and carborundum grit. This was done whenever a stone showed signs of glazing or cutting in spots.

It cannot be assumed that stones in the same lot and grade cut just alike, and although presumably the same, differences in cutting were frequently noted. In this very fine work a variation in the hardness or the least irregularity in grain is quickly revealed by the appearance of the cut.

A broken stone usually ruined the job, and this was the source of some loss. A wire center was used with success, but the stone generally used was not so made. The edges and corners of the stones must be well rounded to prevent chipping or scratching.

It is well known that the appearance of a clean, bright tube—for example, a gun barrel—is deceptive. The repeated reflection of light gives an exaggerated polish. The holes in this case gave the illusion of great brilliance, which was of course increased by bright artificial light or a bright sun. It is only by experience that one can form an idea of the actual condition of a hole. To fix a standard, all holes should be examined under the same kind of light. This is preferably diffused daylight or diffused light from a ground bulb. The latter is more nearly constant.

To examine the hole still more closely, a magnifying mirror set at 45 deg. and mounted so it can be inserted to any point desired will give a very good story of the interior. This should always be used in case of doubt or until the eye has learned to judge correctly.

In closing, it should be stated that the character of the steel on which these observations are all based must be noted, as a change in this alters other conditions. The forgings ran on the average: 0.50 carbon, 0.65 manganese, and 0.30 silicon, with very low phosphorus and sulphur. They were heat-treated to 50,000 lb. elastic limit and about 100,000 lb. tensile strength.

A New Method for Determining the Effect of Speed upon the Strength of Gear Teeth

By WILFRED LEWIS,[1] PHILADELPHIA, PA.

The strength of gear teeth as affected by their speed has been a mooted question for many years and is still awaiting solution. Walker's rules prevailed for fifty years without any known foundation in experiments or analysis, the first analytical treatment of the subject being made by Oscar Lasche in 1899. Since then the experiments of Professor Marx in 1912 pointed to higher values than were given by Walker, but disregarded the analytical work of Lasche which appears to have escaped the attention it deserved until translated and emphasized by Daniel Adamson in 1916.

Impressed by the force of Lasche's analysis, C. H. Logue, in 1920, devised apparatus to measure differentials in velocity ratios and computed increment loads as related to mass and speed. His work was laid before the author at the suggestion of Mr. Adamson in the hope that the gear tester shown and described in the Transactions for 1914 might be utilized in checking up results obtained. The gear tester develops capabilities not originally contemplated in its construction and proves valuable both as an instrument for describing diagrams and as one for measuring exactly the relation of speed to pressure in the loss of initial load.

THE strength of gear teeth as affected by their speed has been a mooted question for many years and various attempts have been made toward its solution, both experimentally and analytically. From a paper on spur gearing by Daniel Adamson, read before the Institution of Mechanical Engineers in 1916, it appears that Reuleaux gave in The Constructor permissible stresses for wood, cast iron, and steel of 2544, 4240, and 14,112 lb. per sq. in., respectively, at speeds not exceeding 100 ft. per min., which stresses he reduced to about half these values for a velocity of 2500 ft. per min.

This work was in the early sixties or thereabouts, and in 1868

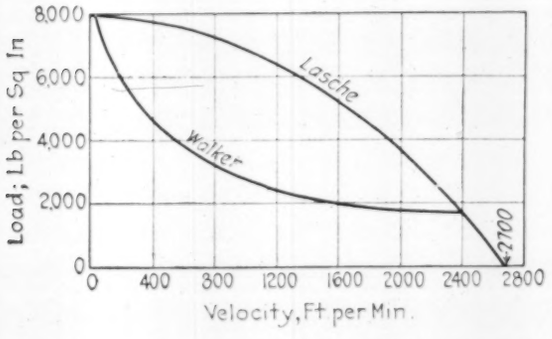


FIG. 1 RATIO OF ALLOWABLE LOAD ON SPUR-GEAR TEETH TO VELOCITY —E. R. WALKER, 1868

E. R. Walker published some data which were embodied in a paper by J. H. Cooper and published in the Journal of the Franklin Institute in 1879. Here factors were given from 3 for slow speed without shock to 14 for a speed of 40 ft. per sec. or 2400 ft. per min.

Nothing appears to show how these values were determined, and in the author's paper entitled Investigation of the Strength of Gear Teeth—read before the Engineers' Club of Philadelphia in 1892—there was nothing he could find more authoritative than Walker's rules, which are worth restating for their simplicity and directness of application. Letting X = breaking load of tooth, lb. = 2000 $P F$; S = working load of tooth, lb.; P = pitch of teeth, in.; F = face of teeth, in., and M = factor of safety = X/S, Walker gave the following values of M:

Speed of wheel rim, ft. per sec.	(a)	3	4	10	15	20	30	40
Values of M		3	4	5	6	8	10	12	14

(a) Very slow speed without shock.

[1] Pres. Tabor Mfg. Co., Mem. Am.Soc.M.E.

Contributed by the Research Committee for presentation at the Annual Meeting, New York, December 4 to 7, 1922, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. All papers are subject to revision.

The effect of speed upon strength may then have been recognized as due to irregularities in forming and spacing the teeth, but the first attempt at an analytical solution of the problem appears to have been made by Oscar Lasche, of Berlin, in 1899. He considered the variations in angular momentum caused by these irregularities and demonstrated that the excess loads due to these variations are necessarily proportional to the square of the speed.

To Walker's rules as shown in diagram by Adamson and reproduced in Fig. 1, another line has been added between the same limits to show the variation in load resulting from the use of the principle enunciated and demonstrated by Lasche.

Both lines run from the static load of 8000 lb. to the allowable

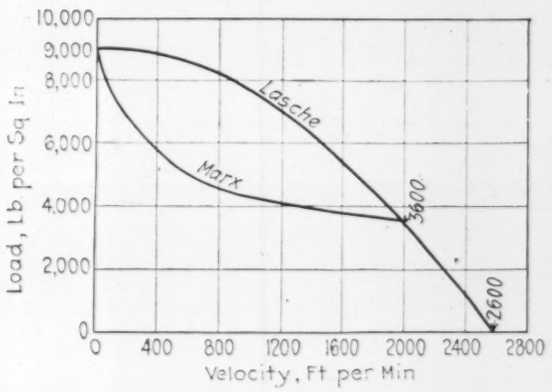


FIG. 2 RATIO OF ALLOWABLE LOAD ON SPUR-GEAR TEETH TO VELOCITY —MARX AND CUTTER, FROM TESTS, 1912

load of 1700 lb. at 2400 ft. per min., and between these limits it will be seen that Lasche gives much higher values than Walker, whose factors for speed have been followed blindly for fifty years. Instead of showing reductions in strength proportional to the square of the speed, Walker shows greater reductions for small differences at slow speeds than for large differences at high speeds, and his loss in strength grows more nearly as the square root of the speed than as the speed squared.

But although Lasche's work in this direction has been generally commended and approved, very little progress has been made in the application of the principles he established. In 1912, however, very elaborate experiments made by Professor Marx of Stanford University were reported, in which gears were broken under various loads and speeds ranging from slow start to 2000 ft. per min. The result of these experiments appear in Fig. 2, also borrowed from Adamson, to which another line has been added showing the working load between the same limits as it would appear for 9000 lb. static and for 3600 lb. at 2000 ft. per min. according to Lasche.

These curves are entirely different in character, that of Walker, which the author adopted reluctantly and tentatively in 1892, and that of Marx running toward the base line as an asymptote while those of Lasche plunge across it and put a definite limit to the speed, depending upon the static load allowable and the accuracy in construction of the teeth. Lasche's curves of strength are parabolic and do not differ essentially from the curve of effective belt pull in the transmission of power, and it is evident that a curve for the power of gears would take the same parabolic form for belt power, reaching its maximum, as for a belt, at a certain speed.

It is also apparent in these diagrams that, according to Lasche, Walker and Marx were not so far apart, Marx starting 1000 lb. higher and crossing the base line at 2600 ft. per min. against 2700 for Walker. In fact, the Lasche lines of strength in Figs. 1 and 2 are almost identical and help to reconcile the differences supposed

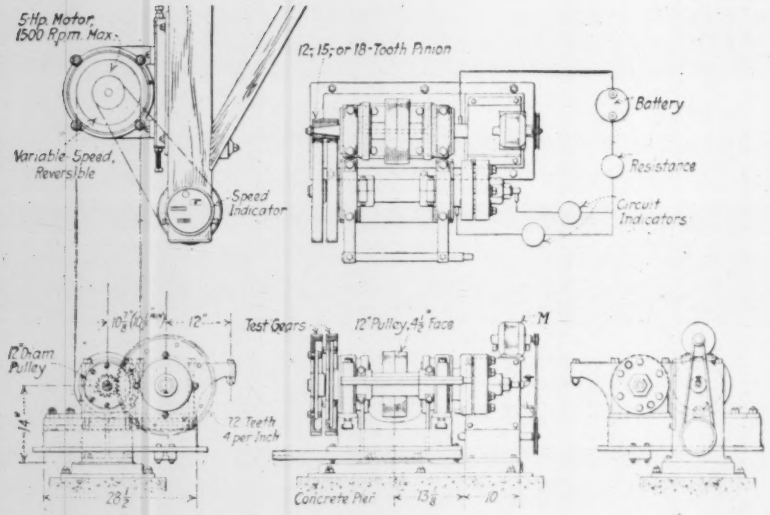


FIG. 3 THE LEWIS GEAR-TESTING MACHINE

to exist between Walker and Marx. If we accept their extreme values and Lasche's principle, we are led to believe that Walker was a close observer and founded his factors upon results obtained under extreme conditions, filling in between as seemed to him reasonable without attempting to prove the intermediate values.

The question may well be asked how such careful experiments as those made by Professor Marx in 1912 seem to sustain, in principle at least, Walker's ancient rule of thumb against the rational conclusions of Lasche; the answer to which calls for further investigation, and it is hoped that the new method here proposed will shed some light upon it. Breaking tests, the author believes, are misleading and should be discouraged for the simple reason that when a gear is broken under any given conditions as to load and speed, it is done for, and it becomes impossible to say what that gear would have shown under some other conditions. So also in regard to inaccuracies in forming and spacing, it is a matter of vital importance that these minute differences be noted in terms of the velocity ratio which they produce, and as nearly as may be under actual working conditions.

In view of the difficulties attending the use of power sufficient to break heavy gears at high speeds, the author was tempted to design a new gear tester as shown and described in the Transactions of the Society for 1914, and afterward built for the University of Illinois in 1916. This was also intended to determine the efficiency and breaking strength of gears under various loads and speeds, but the war intervened and nothing has as yet been reported from its use.

Here again the principle announced by Lasche was overlooked and its was not until the summer of 1920 that the author's interest was revived by a communication from Charles H. Logue, Mem. Am.Soc.M.E., to which attention is here called as being the first step forward in the application of Lasche's principle since its importance was emphasized by Adamson in 1916.

Mr. Logue proposed to produce mechanical diagrams showing in a magnified way the irregularities in velocity ratio for a pair of engaging gears, and from these diagrams to calculate the force of acceleration causing an increment load which, when deducted from the allowable static load, would give the allowable safe load at any speed.

A pair of gears were mounted in bearings and a pair of disks on the gear shaft were connected by a wire, the tension in which caused pressure between the gear teeth. The disks of course bore the same relation to each other as the pitch circles of the gears, and as they turned with the teeth in action, irregularities in velocity ratio would cause more or less slack in the connecting wire, which was multiplied by an index finger. Readings were taken at successive points in the arc of action and the variations in velocity were noted as the data needed in connection with mass to determine the increment load at any speed. This apparatus was modified and improved to give indicator diagrams on paper ribbons or on disks in a closed curve from which the increment load was calculated, and at the suggestion of Mr. Adamson Mr. Logue very freely laid the whole matter before the author to discover if possible whether the gear tester above referred to could be utilized in connection with his problem. So far as the diagrams were concerned, it occurred to the author at once that the gear tester was admirably adapted to their accurate production under conditions that could not be realized so well with any other form of apparatus, but it took all summer to observe that the same machine was equally available for the direct determination of decrement loads rather than increment loads and that it might be materially simplified without detriment as a means for determining the effect of speed upon the strength of gear teeth.

Referring to Fig. 3, the new gear tester is shown to consist as before of a wide-faced pinion mounted in bearings on a swing frame which carries a pair of engaging gears in telescoped shafts, the outer ends of which can be twisted and locked together by a powerful friction clutch. The moment used in twisting is measured by a weighted lever, and this determines the load on the gear teeth acting in equal and opposite directions upon the wide-faced pinion. The friction clutch when tightened secures this load through the resilience of the telescoped shafts, whereas formerly the load on the teeth could be applied or released while running.

A heavy belt pulley on the pinion shaft drives the gears thus loaded and the driving moment can be measured as before by a weigh beam or scales at a certain distance from the turning center of the swing frame in the axis of the pinion shaft. There will be a slight difference in pressure upon the test gears due to this driving moment, which can be easily determined. The belt pulley is driven by a variable-speed motor connected also to a tachometer and revolution counter as may be conveniently arranged, and in this way there is afforded a pair of gears engaging with a wide-faced pinion to run at any desired speed.

Now it is evident that if the teeth are perfectly formed and spaced the gear wheels will run side by side in unison and that such irregularities as may exist will cause them to shift relatively to each other, thus gaining and losing in speed and causing increments and decrements in the load carried on the teeth.

So it occurred to the author, after seeing the results obtained by Mr. Logue, that this shifting of the gears could be made visible by suitable multiplying levers attached to them as shown in Fig. 4 to actuate a scriber moved radially as they turned against a stationary receiving plate. To accomplish this result the scriber is mounted in a link between radius arms so centered as to form a Watt parallel motion and it is made to act under light spring pressure against a plate of smoked glass or photographic film by levers which multiply the differential movement of the test gears about 300 times. Although the Watt parallel motion is not quite perfect, it will be seen that between the limits to which it is here applied it is very simple, effective, and accurate.

The diagrams made in this way require a very slow and steady rotation of the pinion shaft to avoid undesirable momentum in the multiplying levers and this is produced when desired by the small motor *M*, Fig. 3, carried on a gear cover at the end of the pinion shaft. This motor is belted to a light shaft beneath, which engages a train of reduction gears to the heavy pinion shaft. But this train of gearing and all parts used in tracing a diagram are of course disconnected when the test gears are run at speed by the large belt pulley.

If there were no irregularities in the gears the scriber would trace a perfect circle, but since absolute perfection is unattainable, the scriber will move in and out as it turns with the test gears and trace a line indicative of acceleration or retardation, which when interpreted with reference to the masses involved will give the increment or decrement in the load carried on the teeth at any speed. The radial movement of the scriber will show the plus and minus displacements, the mean of which will form the basis for comparisons, and it will be seen that the nearer the curve approaches to a radial line, the greater the intensity of change at that point. Every tooth on both gears will appear for identification in the diagram and a pronounced irregularity can be located at once on the gears.

Here there is no attempt to produce an ideal transmission by means of friction disks or tapes against which irregularities are measured. Each gear forms the basis of comparison for the irregularities of the other, and each is at or near its pitch point when the other is entering or breaking contact. There is nothing to slip or stretch and it is possible by reason of this positive connection to produce diagrams under light or full loads, a comparison of which may reveal the effects of compression and elastic deformations, and it is possible that these effects may modify to some extent Lasche's law of the speed squared. But, however this may be, the results hitherto obtained come from the consideration and manipulation of very minute quantities the multiplication of which may also multiply unsuspected errors, and while working on this mechanism the author endeavored to discover some way of making a direct measurement of the increment load until convinced this was hopeless, and then, reflecting on the decrements entailed by increments as pointed out by Mr. Logue, it occurred to him that when the initial load disappeared with the break in tooth contact there would be a distinct change in the noise, after which he hit upon the better plan now presented of insulating the gears and using an electric circuit to announce through telephone receivers when contact was broken with the pinion by either or both gears.

One or two dry cells as indicated in Fig. 3 are connected by a wire, as shown, to the pinion shaft through which the current passes to the gear wheels in contact and divides in two branches, returning through telephone receivers in each branch to the opposite pole of the battery. The author submitted this suggestion to an electrical expert and was told to rest assured that the breaking of contact between the teeth would be announced by the receivers in no uncertain way, and that variations in pressure might also be expected to make a noticeable change in the sound of the running gears.

So, having set up the desired initial load upon the teeth as explained and taken a diagram on smoked glass to use for printing a permanent record, the idea is to start the motor overhead and watch the tachometer while listening for a change in the sound of the telephone receivers. When this occurs the speed is noted and we know by observation the speed required to reduce the initial load to zero and presumably to increase the speed required to double the initial load. But, while increments and decrements are necessary counterparts in the maintenance of the initial or average load, they are not necessarily of equal intensity, because their durations may be different, and it is thought that the diagram will help to establish the relation between increments and decrements in any given case.

Having determined in this way the increment load for any given speed, it is believed that the result applies to the test gear when running with a flywheel of infinite mass, or very nearly so; because the test gears are substantially equal in mass and flywheel effect, and running as they do with a pinion whose pulley is a massive flywheel, under conditions that impose substantially equal, opposite, and simultaneous reactions upon the pinion, there is no reason to ascribe much if any variation to the movement of the pinion, which runs in consequence as though attached to a flywheel of infinite mass. This may not be strictly true, but it is not far wrong, and it is expected that the increment loads found in this way by experiment can be used to standardize test gears in an absolute way from which the increment loads between any two gears running together may be readily determined. For instance at 1000 ft. per min. we may find in one test gear an increment load of 1000 lb., and in another at the same speed an increment load of 3000 lb.; then when these gears run together the increment load becomes $\frac{1000 \times 3000}{1000 + 3000} = 750$ lb., or, in general $I = \frac{a \times b}{a + b}$, where a and b are the absolute increment loads for two engaging gears at the same speed, and I is the increment load for the same gears running together.

In this way it is proposed to check analysis by experiment and establish upon an indisputable basis the effect of speed upon the strength of gear teeth.

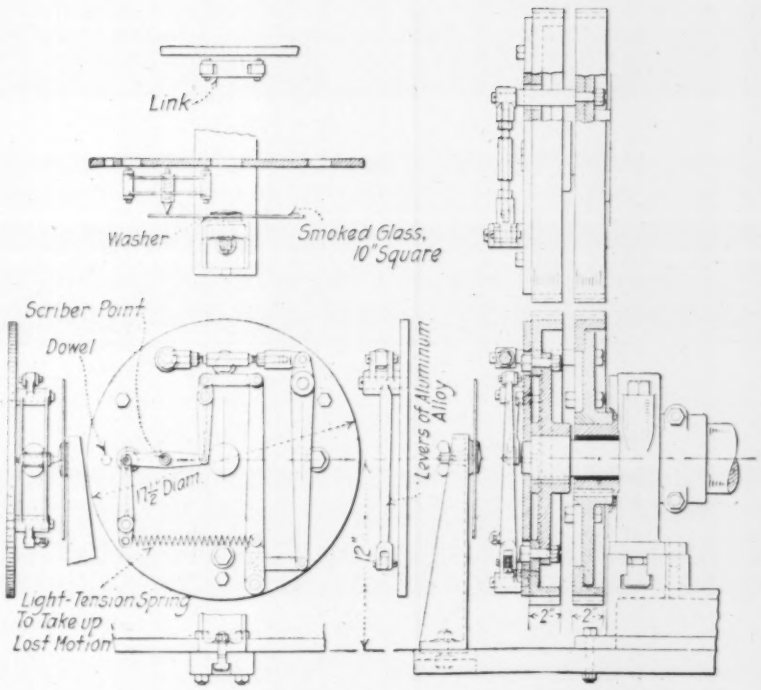


FIG. 4 RECORDING MECHANISM FOR USE ON GEAR-TESTING MACHINE

The importance of better knowledge concerning the effect of speed upon the strength of gear teeth was recognized in December, 1921, by the A.S.M.E. Research Committee and a Research Committee on Gears was appointed by the Council of the Society, consisting of Messrs. Wilfred Lewis, *Chairman;* Earle Buckingham, Ralph E. Flanders, Arthur M. Greene, Jr., and Charles H. Logue, to which the following gentlemen have recently been added by the American Gear Manufacturers Association: F. E. McMullen, The Gleason Works, Rochester, N. Y., and E. W. Miller, The Fellows Gear Shaper Co., Springfield, Vt. A critical examination of the gear tester proposed is in progress and when all details have been satisfactorily arranged it is hoped that interest enough will be aroused in the project to provide funds for the construction of a machine with which a valuable series of experiments can be carried out, throwing light not only upon the effect of speed upon strength, but also upon friction and wear and other questions that may arise for solution.

For the control of gear sounds, the prevention of the generation of noise has been found to be the only feasible method. Other methods, absorption and insulation, have met with slight success. Thus far the only way in which gears have been inspected for noise has been by ear. There has been no quantitative physical measurement of sounds. Sound indicators, which are usually resonators responding only to one pitch, are of little service in measuring gear noise. An indicator for this purpose should be of the non-selective type, such as the pressure vane which responds to the air pressure set up by the noise vibrations.

The measurement of noises is not so difficult as the interpretation of the measurements. Surroundings have much to do with sounds. Results obtained with an indicator in one room would be different than those in another room or out in the open, owing to the reflection of sound vibrations from walls and objects. Also, the gears must be stripped, for if this were not done it would be impossible to determine whether the sounds were attributable to the gears, to the shaft in its bearings, to the gear box, or to the supporting framework.

Noise cannot be measured in absolute units but relative measurements are possible, and from a commercial standpoint these are often all that is desired. All gears compared, however, must be tested under identical conditions, and the sound meter must be located in a calibrated room. Prof. Daniel L. Rich, in an address before the American Gear Manufacturers Association, Chicago, October 9–11, 1922.

A New System of Helical Involute Gearing for Use on Metal Planers

By FORREST E. CARDULLO,[1] CINCINNATI, OHIO

In this paper the author gives particulars of a system of helical gearing designed by him for use on metal planers, in which the directions of rotation and the helical angles of the several gears are so chosen as to counterbalance and minimize end thrust, advantage being taken at the same time of the end thrust to counterbalance the side thrust of the cutting tools. The tooth form adopted is an involute having a 14-deg. pressure angle, a pinion addendum of 3/2 p in. and a pinion dedendum of 1 2 p in., p being the normal diametral pitch. The advantages of this form of tooth for the work in question are enumerated at length and dimensions of a pinion, gear and rack design according to the principles set forth in the paper are given in tabular form.

THIS PAPER presents the engineering features of a system of helical involute gearing of special tooth form developed by The G. A. Gray Company, of Cincinnati, Ohio, to meet the peculiar conditions necessitated by metal-planer service. It is necessary that planer gears should have the following characteristics in order to give satisfactory service:

a The gears must give smooth and uniform motion without impact, vibration, or chatter. If they do not do so, variations in the driving force, or in the speed of driving, will be transmitted to the table, causing it to vibrate, and produce chatter marks on the work

b When the gears wear, they must preserve their correct tooth form so that they will continue to give smooth and uniform motion without chatter

c It is necessary that the gearing have ample strength so that it will transmit the maximum force which can be applied by the source of power, without reaching the elastic limit of the tooth material

d The several gears must have such tooth forms and widths of face that they will run for a reasonable length of time without serious wear

e Should there be wear of the bearings and shafts which would permit the gear centers to separate by a measurable amount, the tooth forms must be such that the gears will still give smooth and uniform motion

f The tooth forms must be such that the teeth can be correctly produced by an efficient and economical machining process.

Disadvantages of Herringbone Gears for Planers

About two years ago it became the duty of the author to design a system of planer gearing embodying the above requirements. On account of requirements *a* and *b*, it was decided to use a complete train of helical or herringbone gearing, and on account of requirements *e* and *f*, to use the involute tooth form. A study of a design using herringbone gearing showed that within the available limits of space this gearing would not have sufficient width of face to meet satisfactory requirements *c* and *d*. The herringbone gear necessitates either that right- and left-hand gears and pinions shall be machined separately and then fastened together in some way, or else that a sufficient space be left between the right- and left-hand teeth to permit the cutters to run out. The first expedient is not only expensive but it gives a weak and unsatisfactory construction of the pinions. Furthermore, the design of a herringbone rack on this plan offers great difficulties. The second expedient makes it necessary to narrow the faces of the gears too much.

A further objection to herringbone gearing for planers is the great practical difficulty of obtaining two helical gears of opposite hand but of exactly equal helical angle, pitch diameter, and pressure angle. A variation in any of these quantities in the two halves of either the gear or the pinion results in an unsatisfactory and "jumpy" action.

Helical gearing having all the desirable qualities of herringbone gearing except freedom from end thrust, it occurred to the writer that the hands and helical angles of the several gears might be so arranged as to counterbalance and minimize the end thrust, and that advantage could be taken of the end thrust to counteract the side thrust of the cutting tools. It is usual in planer work to arrange the tools so that they will feed away from the operating position, commonly called the right-hand side of the planer. Also when a side head is used, it is most convenient and customary to use the right-hand side head. Consequently both the feeding pressure of the rail-head tools and the surfacing pressure of the side-head tool are usually such as to push the table away from the operating side of the machine. These conditions inhere at least 90 per cent of the time in planer work.

It is obvious that if the bull gear be made with a right-hand helix, its rotation during the cut will tend to draw the table toward the operating side of the machine and counteract the feeding

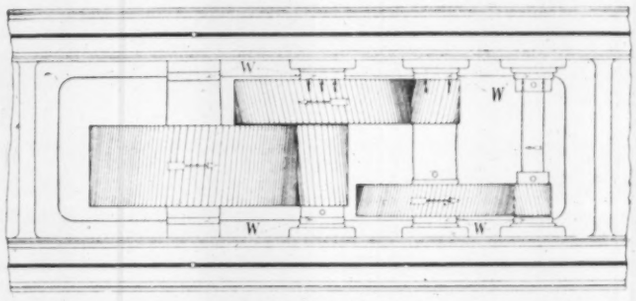


Fig. 1 Arrangement and General Proportions of the Gear Train Devised by the Author for Planer Operation

pressure of the tools. Since this feeding pressure amounts, with usual forms of tools, to about one-tenth of the cutting pressure, the helix angle of 5 deg. 40 min. was fixed upon as being a suitable helical angle for the bull gear and pinion, the end thrust produced by such a gear being approximately one-tenth of the driving force.

The remaining gears of the train were made with helical angles of about 12 deg., the hands of the helices being so arranged that the end thrust transmitted from the bull gear to its pinion is distributed between the bull-pinion, intermediate, and pulley shafts, being greater in the case of the slow-moving shafts than in the case of the pulley shaft. Bronze thrust washers which are provided with oil by a system of forced lubrication, absorb these end thrusts.

End Thrust of Helical Gearing Not Objectionable in Planers

While there may be objections in certain types of machinery to the end thrust produced by helical gearing, these objections do not apply in the case of planers since the driving pressures and its associate end thrusts are relieved each time that the planer reverses, thus permitting complete reestablishment of the oil film. That the end thrust in this design is not serious may be inferred from the fact that it is only about one-thirtieth of the end thrust occurring at the end of the worm shaft in the Sellers type of planer drive which the Gray Company have been building for over thirty years and which does not give trouble when working under thrust-bearing pressures of nearly one ton per square inch.

The arrangement and general proportions of the train are shown

[1] Chief Engineer, G. A. Gray Co. Mem. Am.Soc.M.E.

Contributed by the Machine Shop Division for presentation at the Annual Meeting, New York, December 4 to 7, 1922, of The American Society of Mechanical Engineers, 29 West 39th Street, New York. Slightly abridged. All papers are subject to revision.

diagrammatically in Fig. 1. The feathered arrows show the direction of motion of the tops of the gears during the cutting stroke, while the arrow heads show the pressure exerted by the gears upon the thrust washers.

Imperfections in the action of planer gearing produce a wavy surface on the work known as "gear chatter." If the extreme depth of these waves from crest to trough is not more than 0.0001 in. the planer work will be flatter than can be produced by hand scraping, although the waves can be seen quite plainly under suitable oblique illumination. With improperly designed, poorly cut, or worn gearing, the familiar "washboard finish" appears. The waves may be from 0.0005 in. to 0.0015 in. deep, and the work will have to be hand-scraped to a flat surface if a good job is required. The greater the depth of the waves, the greater the amount of metal which must be scraped away. The cost of this work is properly chargeable against the gearing which makes it necessary.

The Form of Involute Tooth Adopted and Its Advantages

Consequently no portion of our gear design has received more careful attention than the tooth form. The form adopted is a $14^1/_2$-deg. pressure-angle involute tooth, with a pinion addendum of $3/2p$ in., and a pinion dedendum of $1/2p$ in., where p is the normal diametral pitch.

The advantages of the tooth form adopted are:

a The use of a short dedendum in the pinion teeth eliminates interference, which is a prolific source of trouble in all kinds of machine-tool gearing

b The strength of the pinions is increased about 40 per cent without using stub teeth or increasing the pressure angle. This may be seen by comparing the tooth forms shown in Fig. 2

c The use of long addendum and short dedendum for the driving pinions shortens the angle of approach and lengthens the angle of recess. This type of tooth action is sometimes called "long follow through" and gives great smoothness of motion for the following enumerated reasons:

1 During the angle of approach, the effect of tooth friction in causing vibration is cumulative, the friction increasing the effective pressure angle and the tooth pressure, which in turn increases the friction. This exaggerates the periodic variation in the amount and direction of the tooth pressures. During the angle of recess the increase in friction reduces the effective pressure angle and the tooth pressure, thus damping any vibrations produced by variations in friction. The effects of these actions are similar in a general way to those obtained by pushing a flexible pole along a rough road in front of one in the case of the angle of approach, and dragging it after one in the case of the angle of recess. In the first of these cases the vibration is very marked. In the second it is scarcely noticeable

2 The active portion of the tooth profile is removed from the base circle so that the involute curvature changes gradually, giving a smoother action

3 During the angle of recess there is less relative sliding than during the angle of approach, which reduces tooth wear.

d The diameter of the pinions at the bottom of the teeth is increased, giving stronger pinion bodies

e The short dedendum avoids undercut or radial flanks with their attendant evils.

In order that the advantages of long-addendum drivers shall not be lost in the case of the bull gear working against the rack, the bull pinion, bull gear, and rack are of peculiar kinematic properties. The bull pinion is a long-addendum driver of $14^1/_2$ deg. pressure angle, and the bull gear, when meshing with the pinion, is a long-dedendum driven gear of the same pressure angle and cut with an exactly similar hob of opposite hand. When the bull gear meshes with the rack, however, it becomes a long-addendum driver, the change being produced by appropriately reducing the pressure angle, the circular pitch, and the helical angle of the rack. The bull gear accordingly has two pitch circles, the larger one associated with the bull pinion and the smaller one with the rack. Each pitch circle has its own circular pitch and helical and pressure angles. Were it not for this design, most of the action of the bull gear and the rack would occur during the angle of approach, when the circumstances are unfavorable to smooth action. By this peculiar construction, however, we achieve the following advantages:

a The bull gear drives the rack mostly during the angle of recess, giving the advantages already described in connection with the long-addendum pinion

b The pressure angle of the bull gear against the rack is theoretically only about $8^1/_2$ deg., and is practically reduced still lower by the tooth friction, greatly diminishing the tendency to vertical vibration[1] arising from imperfect gear action or variation in tooth friction

c The line of action of the force applied by the bull gear to the table of the planer being more nearly in the direction of the motion of the table, is much more effective and satisfactory

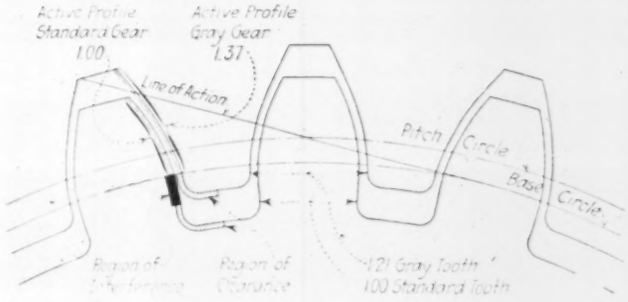


FIG. 2 COMPARISON OF THE GRAY AND STANDARD FORMS OF INVOLUTE TEETH

d Because of this very low pressure angle the tendency of the bull gear to lift the table is only about half the usual amount,[2] making hold-down gibs and side-thrust bearings unnecessary.

e Because of the low pressure angle the number of teeth in contact is greatly increased, which confers the following advantages:

1 The load per tooth is reduced in much greater proportion than is the strength of the tooth, so that the construction is actually stronger than would be the case with the larger pressure angle

2 The effective lineal contact is greatly increased, reducing the specific contact pressure and consequent wear.

Reasons for Employing a Full-Length Tooth and a Low Pressure Angle

A few words of discussion as to the reason for choosing the full-length tooth, that is, a tooth where the working depth is equal to 2 divided by the diametral pitch, and also for choosing the low pressure angle, are in order.

In the case of spur gears which have become slightly worn, some wear occurs at the tips of the teeth and still more on the

(*Continued on page 873*)

[1] Gear chatter is caused by periodic variation in the amount and direction of the tooth pressure. Such variations when finally transmitted to the table rack have two components, one in the direction of motion and the other in a vertical direction. The first of these components is harmless, the second produces vertical movements of the table and work. A low pressure angle between the bull gear and table rack tends to eliminate this vertical vibration.

[2] In this connection the author desires to point out that conditions occasionally arise when a left-hand side head is being used or heavy roughing is being done by feeding the tools toward the operating side, that the end thrust of the bull gear adds to instead of counteracting the tool pressure. Under these unusual conditions the bull gear pushes the table against the right-hand surfaces of the ways. This tends to cause the table to lift. However, the pressure angle of the bull gear in the Gray design is such that even under these unusual and unfavorable conditions the tendency of the table to lift is less than the tendency of a spur-geared table to lift under the most favorable circumstances.

The Fuel Element in Energy Production Costs

S. B. FLAGG,[1] NEW YORK, N. Y.

THE executives responsible for the operation of steam-electric public-utility properties have had a troublesome problem in their rising fuel costs during the last few years. Of the total cost of delivering a kilowatt-hour to the switchboard, fuel represents anywhere from 60 to 80 per cent, and this item has consequently been the one upon which has been concentrated the greatest effort to reduce production costs. It will be the purpose of the present discussion to point out some of the most important ways in which this fuel-cost item may be reduced. The opportunities for saving begin with the consideration of the location for the development and do not end until the last unit in the plant is dismantled or placed in reserve.

If the station is to serve a city of some size located far from the source of fuel supply, the selection of site will frequently be determined by the availability of condensing-water supplies. If, however, the community to be served is not at a great distance from these fuel sources, and particularly if the station is to feed into a transmission system distributing energy to several communities, the selection of site may have a marked effect upon fuel costs.

There may be possibility of drawing fuel from two or more competitive coal fields if the proper location is chosen, and in some cases it may be advisable to look forward to shifting from one of these to the other, even though the fuels may be of radically different character. Nowadays, however, freight rates bear little relation to the length of haul, and sometimes the difference in rates applying to two sites only a mile or two apart may increase the cost of delivered fuel by as much as 30 per cent and thus practically preclude the possibility of obtaining competitive fuel bids.

There are cases where advantage may be taken of supplies of waste fuels, such as the so-called "river coal" in the streams flowing from the anthracite coal regions or the refuse from lumbering operations. If the supplies of such fuels are adequate to furnish the requirements of the station for a number of years and they may be purchased on favorable long-term contracts, this condition may prove the deciding factor. When combined with the supplies of waste fuel there is the possibility of eliminating common-carrier transportation from the source to the station, this is a further decided advantage. Occasionally a plant may be built near enough to a coal mine to secure this elimination of freight charges. In the last few years there has been much discussion about the generation of energy in large central stations located in the eastern coal regions, but one of the great obstacles has been to find adequate supplies of condensing water immediately adjacent to the mines. The very important bearing of site selection on fuel costs was well illustrated by a comparative study recently undertaken. Although the sites were only about 25 miles apart, the estimates showed the fuel cost per kilowatt-hour at one plant to be 1.5 mills lower than for a development at the other site. Assuming a peak load of 30,000 kw. and an annual load factor of 60 per cent, this would mean an annual output of approximately 160,000,000 kw-hr., on which a saving of 1.5 mills per kw-hr. would amount to $240,000. Looking at the matter in a different way, the fixed or investment charges on such a station would probably be around 5 mills, so that the estimated difference in fuel costs would, in so far as the effect upon energy cost is concerned, be equivalent to a 30 per cent saving in the investment at one site as compared with the other.

Once the question of station site is settled and the problem is put up to the designing engineer, he, too, must keep fuel costs constantly in mind in developing the general plant layout as well as in determining what equipment shall be installed, for the decision will frequently depend upon the balance between decreased fuel expense and increased fixed charges, or vice versa. This applies to the arrangements for coal and refuse handling, the selection of steam-generating equipment and prime movers, and even to the choosing of auxiliaries. Flexibility in the boiler plant so as to permit taking advantage of changed fuel-market conditions may require careful consideration. This is especially true in some localities in the Middle West where it may pay to change from fuel oil to natural gas or from liquid or gaseous fuels to coal, sometimes for a period of only a number of months.

A number of public-utility companies have decided to acquire and operate their own coal mines as a means of reducing their energy costs, one of the chief inducements being that their exceptionally uniform demand for fuel gives such mines a high "load factor." This is readily apparent when we consider that mines in some sections of the country often average only about 200 working days per year and that coal properties have certain expenses which go on whether or not the mines are operating. Another advantage resulting when the utility company produces its own fuel is that the quality and characteristics of the coal are subject to less variation, and this is a distinct advantage in the plant operation.

If, as in the great majority of cases, the utility company does not control its source of fuel, there is the opportunity to reduce operating costs by the judicious purchase of its supply, and executives have today a much more general realization of this fact than formerly. The comparative values of different fuels as reflected in the fuel cost per kilowatt-hour are now much more carefully studied than formerly. Under some conditions a reduction of 1 per cent in the ash content of the coal may be equivalent to a saving of 25 cents or more per ton in the price of the coal, and this fact justifies not only careful thought in making contracts or purchases, but also in checking deliveries. Further use is made of delivery coal analyses in following up operating performance, for the station economy is now reported in B.t.u. per kw-hr. instead of pounds of coal per unit output.

The marked growth of the plant-betterment work in public-utility organizations is largely on account of the importance of the fuel element in operating costs. As a consequence of these activities and of the availability of improved boiler and stoker-equipment monthly operating reports, the results, being obtained today in some stations are better than were possible formerly under test conditions. For instance, the weekly or monthly boiler-refuse samples from some of the best-operated and most modern installations are showing as low as 10 per cent combustible in the dry refuse, whereas formerly 15 per cent was considered excellent for test conditions. Likewise, gas analyses showing only 15 to 20 per cent excess air are being obtained in daily operation, and monthly average boiler-plant efficiencies close to 80 per cent. By careful study of station heat-balance conditions, of condenser and often of spray-pond operation, as well as the economical loading of equipment, the savings in boiler room and turbine room have in some cases reduced fuel consumption as much as 30 per cent.

Finally the time comes when the boiler or turbine units in the station or even the station as a whole are placed in reserve or superseded by something more efficient and usually of larger capacity. The demand for increased capacity may precipitate such a decision, but if not, the differences in fuel economy will bring it about. In fact, the rapid growth in the electrical loads of our utility plants, necessitating frequent extensions to existing generating facilities or the commencement of new developments, has been due in large part to the unceasing efforts of the executives to improve fuel economy and lower costs of production. As the reward of these efforts we see today the larger and most modern steam-electric stations producing a kilowatt-hour with the consumption of 18,000 to 19,000 B.t.u. in the fuel, where formerly it required 50,000 B.t.u. or more, and the end is not yet. With the continued improvement of efficiency in transmission of electrical energy we may expect greater centralization of energy generation, and far-sighted executives are so shaping plans for development that they will be able to meet the competition which this centralization may make possible. In the struggle to attain to this position the field of fuel economy in its broadest sense offers the greatest single opportunity at the present time.

[1] Engineer, Electric Bond & Share Co.

Presented at a meeting of the Washington Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Washington, D. C., March 23, 1922. Abridged.

Relieving Industry of Burden

By WALLACE CLARK,[1] NEW YORK, N. Y.

Many manufacturing plants are today carrying a burden of idleness and waste because their capacity, which was increased during the war and the period of high prices immediately following, is in excess of present demands. This paper presents a general plan for lifting this burden, important features of which are distributing overhead expenses by the machine-rate method; keeping all equipment in use, even though it be necessary to reduce prices to secure orders; reducing manufacturing time; and lowering production costs, particularly by raising production standards and stimulating the interest of the workmen.

AMERICAN industry is at present carrying a heavy burden of unused buildings and equipment and of wasted time. Long before 1919 we had become an exporting nation and had increased the capacity of our manufacturing plants far beyond our domestic needs. When the European nations went to war we added to our factories in order to provide them with munitions and food, and after our entrance into the war, the expansion was even greater. After the armistice the lure of high prices and big profits caused still further additions to plants and equipment, so that we are now greatly overequipped for our own needs, and there is no immediate prospect of a resumption of foreign trade.

How, then, are manufacturing plants to be relieved of this burden of idleness and waste?

First, by using all equipment

Second, by doing work with as little waste as possible.

In attempting to take the first step, it is necessary to begin by separating used from unused equipment. This separation need not be made physically, but it must be clear in the minds of the management, particularly those who have anything to do with costs and prices.

Costs of Work and Idleness

Among manufacturers who are keeping abreast of the times it is generally accepted that the best way to distribute overhead expense is by means of a machine rate.[2] Material which stands on the floor of a shop is not affected by the investment in the equipment or the building, except possibly in the matter of protection from the weather. It is only when that material is worked on by men, machines, chemical processes, or in other ways that the investment in equipment or the expenses have any effect on it. The plant affects material only through machines; therefore the fairest method of distributing the plant expense is according to the time spent on the material by the various machines, that is, by means of machine-hour rates.[3]

From an operating standpoint the overhead expense may be divided into two parts:

1 The cost of keeping equipment and having it ready for use

2 The added cost when equipment is used.

In distributing this expense there are therefore two rates for each machine, an idle rate and a running rate.

These two machine rates provide a means for keeping costs of idleness entirely separate from costs of work done. When a machine is being used, it is obvious that through its running rate the overhead is charged directly to the product; but when the machine is not running the overhead is not being used and cannot be charged to the product because it has no effect on the product. However, it may be charged to accounts which represent the reasons for the idleness. In a machine shop, for instance, there would be such idleness accounts as Lack of Help, Lack of Material, Lack of Orders, Lack of Power, Repairs, and Lack of Tools. These expenses cannot be charged to the product, so they must be kept separate and possibly absorbed in "profit and loss." When the manager, superintendent, and, particularly, the foremen know the amount of out-of-pocket expense due to causes over which they have control, they will invariably so plan their work as to lessen this burden of idle equipment.

Losses Due to Lack of Orders

When the cost of maintaining equipment in idleness due to lack of orders is known, intelligent steps can be taken to reduce that loss. The sales department will examine the situation and see what advertising or soliciting can be done to bring in orders at profitable prices. If satisfactory results are not obtained, the price will be lowered to a point which will secure orders, provided that the price covers the expense incurred for material, direct labor, power, etc., in filling the orders. Whatever is received above the material-labor-power cost will go toward reducing the losses caused by the idleness of machines. It is often possible to wipe out all the burden of idleness expense by quoting prices low enough to keep machines running.

However, if conditions are such that even in normal times there is no prospect of securing orders at a profit, there is no advantage in continuing to quote low prices. There are then two courses open:

1 To develop new products which can be manufactured with this equipment and sold at prices which will produce a profit

2 To sell the equipment and use the space for the manufacture of some other product.

Either course will remove what remains of the burden of unused equipment. During the last two years investors have come to realize that idle capital is frequently unable to secure any return, and they are inquiring into the cost of idle buildings and equipment, fixing the responsibility for their idleness, and insisting that every possible step be taken to make use of them.

Eliminating Waste

Going back to our second step toward relieving the burden—that is, by doing work with as little waste as possible—all waste in industry may be traced to the waste of man's time. But money is our medium of exchange for time, therefore wastes are most easily detected by investigations of costs. A comparison of actual costs of work done with ideal or standard costs will reveal the wastes and lead to their elimination.

Great savings can be secured by simplifying the product, reducing the number of varieties, and manufacturing in quantities wherever possible.

One of the striking wastes in many plants is the unnecessarily large investment in inventories of raw material, work in process and finished goods. In order to maintain satisfactory control over an inventory, an accurate and up-to-date record of quantities in stores, of receipts, and of issues must be kept in the office of the stores department; order points must be so marked that when they are reached the office can be notified, its records checked, and the necessary orders for additional quantities placed. The amount to be kept in stores will depend on:

1 The time required to replenish the supply, either by manufacture or purchase

2 The amount used during that time.

A reduction in the time required to replenish the supply brings about a corresponding reduction in the inventory. When material moves slowly through a plant or stands on the floor or on shelves waiting for a workman or for additional material, not only is the inventory of work in process increased but also that of finished goods, because a sufficient quantity of finished goods must be carried in stores to meet the sales during the time a new supply is being manufactured. The longer it takes to manufacture, the

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[1] Industrial Engineer. Mem. Am.Soc.M.E.

[2] Organizing for Work, by H. L. Gantt (Harcourt, Brace & Howe, 1919); Cost Accounting and Burden Application, by Clinton H. Scovell (D. Appleton & Co., 1920); Principles of Factory Cost Keeping, by Edward P. Moxey (Ronald Press, 1920); Proper Distribution of Expense Burden, By A. Hamilton Church; Cost Accounting to Aid Production, by G. Charter Harrison (Engineering Magazine Co., 1921); and Bookkeeping and Cost Accounting for Factories, by William Kent (John Wiley & Sons, 1918)

[3] The term "machine-hour rate" is intended to include rates for floors benches, vats, and, in some cases, men.

Contributed by the Management Division for presentation at the Annual Meeting, New York, December 4 to 7, 1922, of The American Society of Mechanical Engineers. All papers are subject to revision.

more finished goods must be kept in stores and the heavier will be the burden of inventory.

Reducing Manufacturing Time

In order to reduce the manufacturing time, that is, the time required for the material to move through the plant until it becomes finished goods, the way must be cleared and the material kept moving. However, before the way can be cleared, a decision must be reached as to what work is to be done on this material. A written record must be made of the kind and quantity of material required, the operations to be performed, the machines on which the work can be done, the special tools or fixtures required, and the time which each operation will be reasonably expected to take. This information should be supplemented by detailed instructions as to how the work is to be done, either in the form of blueprinted shop drawings or typewritten instructions.

These instructions should represent the best available knowledge in the plant as to the material and processes which will produce goods of the desired quality, and should be the combined knowledge of the foremen, workmen, engineering department, and the management. When there is a difference of opinion as to methods, it is necessary for all of these departments to agree as to which method is best and rigidly adhere to this agreement until they are all convinced as to the wisdom of a change.

When a decision has been reached as to the work to be done on an order, the way can be cleared through the plant; that is, material, special tools, and fixtures can be ordered, and the necessary time of machines and operators set aside. This, of course, can be done only when the management has a fairly complete knowledge of the capacity of the machines and operators, as well as knowledge of the time required to complete the work already in the plant.

Orders can be then issued to the various foremen telling them what operations are to be done in each department, how, and when. There should not at any time be doubt in a foreman's mind as to the comparative importance of the work ahead of him.

When the foreman has before him the various orders to be worked on, it is necessary for him to so plan his work as to make the best possible use of his machines and men and yet get the orders out at the proper time. He will each day advise the management what he expects to do the following day and also report the things which he had been instructed to do but which he knows he will not be able to do, with the reasons why. In this way he keeps the management informed as to the progress he is making and the obstacles which prevent his progress. (It will be noted that this method places more responsibility on the foremen than has been usual in the strongly centralized organizations often identified with scientific management.)

The plant management compares these records of work done received from the foremen with the plans which it has already made, in order to see that the material moves through the plant at the desired rate of speed. Whenever its progress is checked, the management is enabled to concentrate its attention on overcoming delays, which add a considerable weight to our industrial burden.

Lowering the Cost of Production

The part of the work of management described above, that is, keeping the work moving through the plant at a rapid pace, should be well organized before very much time is devoted to individual production, because the delays under the control of the management are usually much greater in extent than those under the control of individual workmen, and because improvements in the management will have an appreciable effect on the output of the workmen. It is only when the plant is properly organized that satisfactory standards of accomplishment can be formulated with which to compare actual production. Such a comparison, when made by the foreman himself, enables him to give the workman whatever help or instruction he may need in order to do his work in accordance with the best knowledge in the plant. It is then time to investigate the processes themselves, to develop better methods and better equipment, and to teach the workmen how to use these new methods.

Finally, the interest of the workmen themselves must be stimulated. Those who dislike monotony must be provided with a rotation of work and an opportunity to develop their creative abilities; those who dislike learning new methods should have their interest aroused by the constant comparison of their production records with the standards and by receiving extra compensation for doing the work within the standard time.[1]

Lifting the Burden

This burden of idleness and waste can be lifted from the shoulders of manufacturers only by their own efforts. Each one must get at the facts in regard to his own plant, and he can check them up with a general plan such as is here presented.

In order to *use all equipment*, he will—

1 Get costs of idleness
2 Remove causes of idleness under the control of the plant management
3 Reduce idleness due to lack of orders by:
  a Advertising or soliciting
  b Lowering prices
  c Developing new products
  d Selling equipment.

In order to *do work with as little waste as possible*, he will—

1 Simplify his product and reduce varieties
2 Reduce inventories by:
  a Control of stores
  b Reducing manufacturing time.
3 Lower the cost of production by:
  a Getting workmen to use available knowledge as to methods
  b Improving processes
  c Stimulating the interest of his workmen.

When individual manufacturers have solved this problem for themselves, it will be found that the burden has been lifted from American industry.

The executive who aspires to "sell" his institution, as an institution, to the public will concede that it is equally important, if not more so, to sell it to its employees. To make men and women see that they are working not primarily to make dividends for other men and women but for an institution that is recognizedly of universal service; and that through it their labor is promoting that service, is to apply one of the strongest possible antidotes to discontent and strife.

Various efforts are being made to sell concerns to those who work for them. What else are pensions, bonuses and group insurance? These all have their value—and a very practical value.

There is no denying the strength of the appeal made by wages, by hours, by working conditions. But there is another powerful appeal that too seldom is tried—the appeal that lies in the recognition of each person connected with the concern as an individual; not as merely a cog in the machine. It is small wonder that the man who is regarded by his employers as a cog comes to think of himself in the same light and to take no more interest in his work than a cog.

There must be differences in responsibility and authority among those who comprise the personnel of a factory or store force; there need be no difference in the dignity of their positions, nor graduations of the courtesy accorded them. This matter of courtesy is more vital to harmony and loyalty than is sometimes recognized.

That the selling of an institution is no idle dream, but a practical possibility, is proved by practically every newspaper. Newspaper men work overtime when it is necessary simply for the glory and prestige of the paper, which to them is an entity, with a being and soul of its own.

It will take time to put the institutional idea over among industrial organizations. But its success will usher in an era of peace, efficiency and prosperity in the industrial and commercial world that will make the effort more than worth while.—C. P. Bulkley, in *Industrial Management*, November, 1922, p. 279.

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[1] See Making Work Fascinating as the First Step Toward Reduction of Waste, by Walter N. Polakov, Mechanical Engineering, November, 1921, p. 731.

Influence of Design on Cost of Operating Airplanes

By ARCHIBALD BLACK,[1] GARDEN CITY, N. Y.

The author discusses cost of operating commercial airplanes and endeavors to clear up prevalent misunderstandings. Curves of operating cost for varying duration, speed, reserve horsepower, etc., are developed. Calculations are made to illustrate the impracticability of requiring twin-engined commercial airplanes to fly on one engine, and initial rate of climb of 400 to 500 ft. in the first minute is proposed as the standard of safe performance. Air Mail Service costs are used to show that airplanes designed for commercial use and fully loaded can be operated at a total cost of from 0.030 to 0.032 cent per pound-mile or 6.5 cents per passenger-mile, exclusive of the cost of obtaining the business.

THIS paper has been prepared with the intention of exploding certain widely held fallacies regarding the performance for which commercial airplanes should be designed. It presents the results of a study of the relation between designed performance and unit operating cost for such airplanes. The data were compiled by the former firm of A. & D. R. Black on work for its clients, and should be regarded as forming a qualitative rather than quantitative analysis. That is, the data given, while capable of general application to all types, will be slightly modified in the case of machines radically different from the conventional type considered.

The most generally held erroneous ideas regarding commercial airplanes are probably the following: (1) That duration of flight of eight or even ten hours is practicable; (2) that speeds of 125 to 130 m.p.h. or more are practicable; (3) that a twin-engined machine should be capable of flying with one engine running; (4) that a factor of safety of eight or more is desirable; (5) that comparatively high climbing ability is necessary and practicable; and (6) that very large airplanes are the most suitable for commercial use. While such notions are most common among those without experience in the design or operation of airplanes, they have sometimes been advanced by others who have less excuse. Probably this misunderstanding is due to the frequent practice of using for commercial work machines not suited to this purpose.

The presumption is made here that commercial airplanes are designed primarily for operation at a profit, so that operating cost and safety become the most vital considerations. When this work was started it was found possible to eliminate some duplication by basing many of the calculations upon a British report on the division of total weight of different airplanes.[2] Fig. 1 is reproduced from this report with data on weights and horsepower added.

Weight Division vs. Size, Duration, and Speed

As a preliminary to consideration of the variation of unit operating cost with size, duration, speed, etc., it becomes necessary to study the variation of net pay load with these elements. Figs. 1 to 6 should be regarded merely as furnishing the data necessary for later curves and may be passed over with little comment. They are included here because of their value for reference. Each figure shows the variations of pay load with other elements for a series of airplanes similar in every respect except in the particular feature under consideration. It will be noted that in Fig. 1 the assumption is made that only wing weights vary appreciably with size and factor of safety. While not strictly correct, the error is very slight.

In Figs. 2 and 4 single Liberty-engined airplanes have been considered, while in Figs. 3 and 5 those dealt with are twin Liberty-engined airplanes. Fig. 6 includes the two types. These machines may be regarded as typical of commercial airplanes. All corrections have already been made so that the net pay load can be read directly. The "theoretical number of passengers" scales are so marked because they indicate the number of passengers which the machine can actually lift. Other design considerations, particularly the size of the fuselage, may make it impracticable to accommodate the full number. In Fig. 11, later, the assumption is made that twelve passengers is the limit for a machine of about 420 hp. and that this limit varies directly with the horsepower. This is somewhat arbitrary but is based upon experience and should be regarded as an ultimate limit. For ordinary practice, ten instead of twelve passengers should be taken as the present limit for this size of airplane.

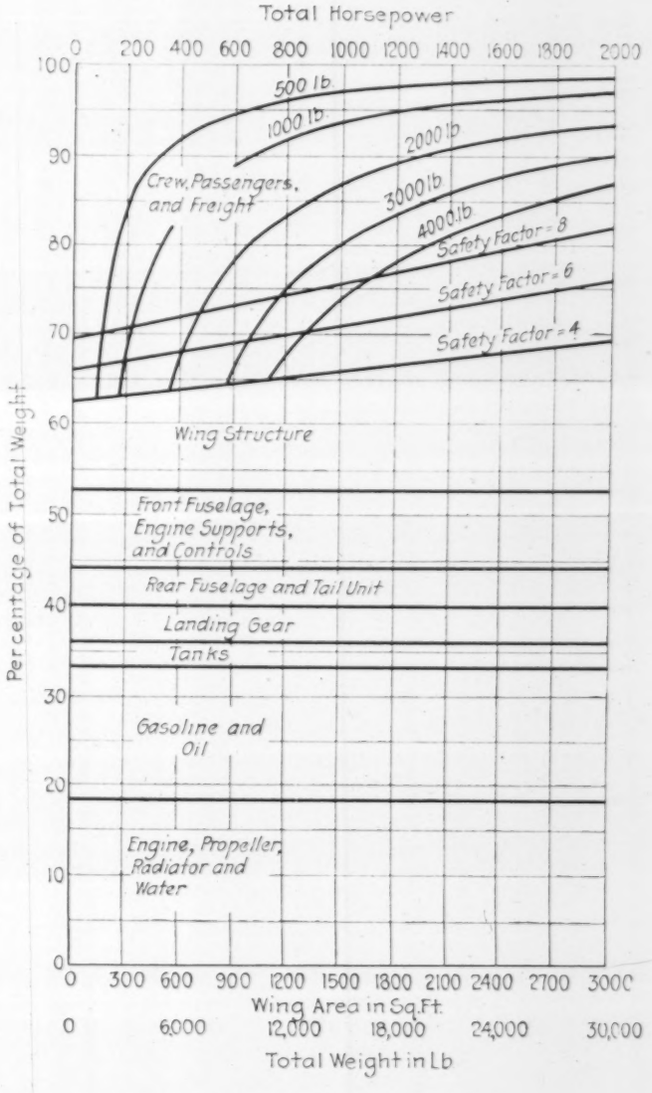
Total Horsepower
0 200 400 600 800 1000 1200 1400 1600 1800 2000
500 lb
1000 lb
2000 lb
3000 lb
4000 lb
Crew, Passengers, and Freight
Safety Factor = 8
Safety Factor = 6
Safety Factor = 4
Wing Structure
Front Fuselage, Engine Supports, and Controls
Rear Fuselage and Tail Unit
Landing Gear
Tanks
Gasoline and Oil
Engine, Propeller, Radiator and Water
Percentage of Total Weight
100 90 80 70 60 50 40 30 20 10 0
0 300 600 900 1200 1500 1800 2100 2400 2700 3000
Wing Area in Sq.Ft.
0 6,000 12,000 18,000 24,000 30,000
Total Weight in Lb

FIG. 1 DIVISION OF WEIGHT OF FULLY LOADED AIRPLANES
(For condition of 10 lb. per sq. ft., 15 lb. per hp. and 4 hr. duration. Curved lines represent conditions of constant useful loads.)

Operating Cost

Available data on the cost of operating commercial airplanes on a comprehensive scale are very limited and practically confined to the records of the U. S. Air Mail Service. The author's association with this organization as its consulting engineer some time ago gave him an opportunity to study it at close range and he feels satisfied that it may be regarded in every way as a commerical air line. Incidentally, it is incontestably the largest commercial air line in the world. Careful and fairly complete records have been kept of the cost of operating this service and the figures which they give form the most trustworthy information at present available. The allowance which has been made for interest on investment is

[1] Consulting Aeronautical Engineer, Garden City, N. Y., Mem. Am. Soc.M.E.

[2] British Advisory Committee for Aeronautics, Reports and Memoranda No. 676.

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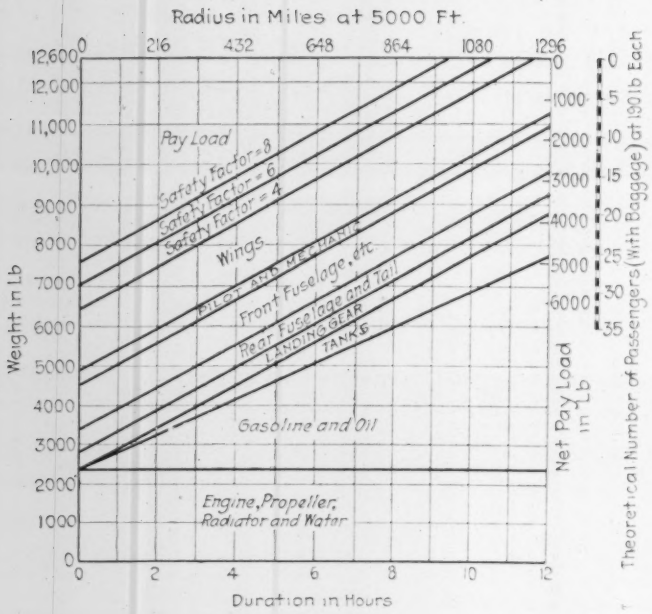

Radius in Miles at 5000 Ft.
0 216 432 648 864 1080 1296
12,600 12,000 11,000 10,000 9000 8000 7000 6000 5000 4000 3000 2000 1000 0
Weight in Lb
Pay Load
Safety Factor = 8
Safety Factor = 6
Safety Factor = 4
Wings
Pilot and Mechanic
Front Fuselage, etc.
Rear Fuselage and Tail
Landing Gear
Tanks
Gasoline and Oil
Engine, Propeller, Radiator and Water
0 2 4 6 8 10 12
Duration in Hours
0 1000 2000 3000 4000 5000 6000
Net Pay Load in Lb
0 5 10 15 20 25 30 35
Theoretical Number of Passengers (With Baggage) at 190 Lb Each

FIG. 2 VARIATION OF WEIGHT DIVISION WITH DURATION—420-HP. AIRPLANE

(One 420 hp. Liberty engine; total weight, 6300 lb.; wing area, 630 sq. ft.; high speed, 108 m.p.h. at 5000 ft.; minimum speed, 57 m.p.h.—10 lb. per sq. ft.; climb from sea level, 565 ft. in first min.)

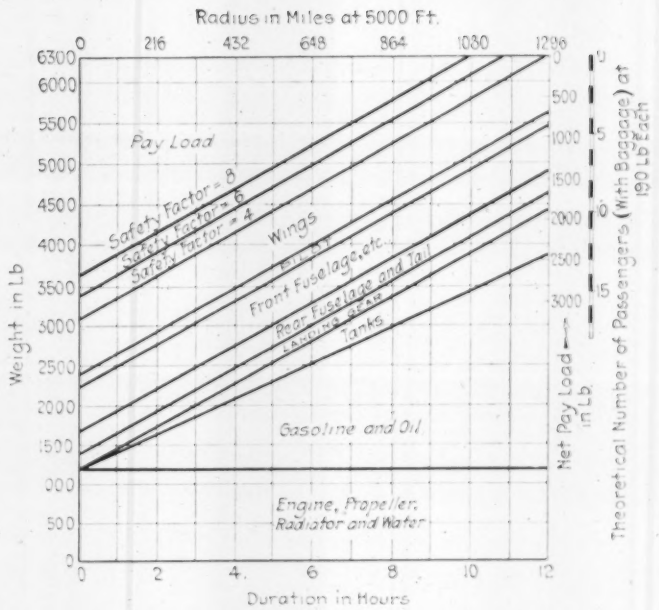

Radius in Miles at 5000 Ft.
0 216 432 648 864 1080 1296
6300 6000 5500 5000 4500 4000 3500 3000 2500 2000 1500 000 500 0
Weight in Lb
Pay Load
Safety Factor = 8
Safety Factor = 6
Safety Factor = 4
Wings
Pilot and Mechanic
Front Fuselage, etc.
Rear Fuselage and Tail
Landing Gear
Tanks
Gasoline and Oil
Engine, Propeller, Radiator and Water
0 2 4 6 8 10 12
Duration in Hours
0 500 1000 1500 2000 2500 3000
Net Pay Load in Lb
0 5 10 15
Theoretical Number of Passengers (With Baggage) at 190 Lb Each

FIG. 3 VARIATION OF WEIGHT DIVISION WITH DURATION—840-HP. AIRPLANE

(Two 420-hp. Liberty engines, 840 hp.; total weight, 12,600 lb.; wing area, 1260 sq. ft.; high speed, 108 m.p.h. at 5000 ft.; minimum speed, 57 m.p.h.—10 lb. per sq. ft., climb from sea level, 565 ft. in first min.)

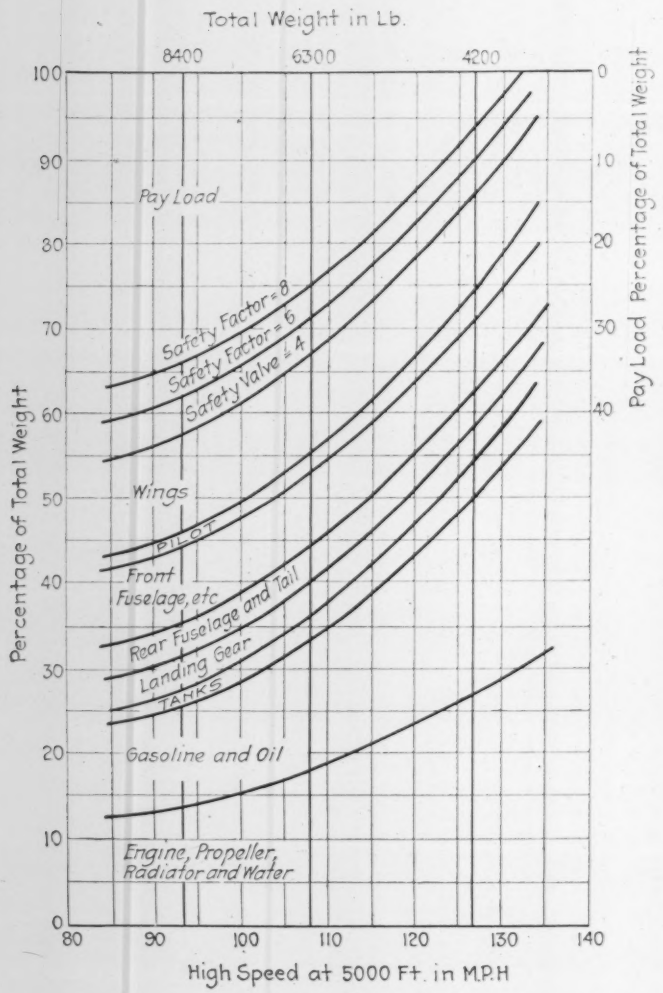

Total Weight in Lb.
8400 6300 4200
100 90 80 70 60 50 40 30 20 10 0
Percentage of Total Weight
Pay Load
Safety Factor = 8
Safety Factor = 6
Safety Valve = 4
Wings
Pilot
Front Fuselage, etc
Rear Fuselage and Tail
Landing Gear
Tanks
Gasoline and Oil
Engine, Propeller, Radiator and Water
0 10 20 30 40
Pay Load Percentage of Total Weight
80 90 100 110 120 130 140
High Speed at 5000 Ft. in M.P.H.

FIG. 4 VARIATION OF WEIGHT DIVISION WITH SPEED—420-HP. AIRPLANE

(Liberty engine, constant minimum speed, 57 m.p.h.; 4 hr. duration; wing loading, 10 lb. per sq. ft.)

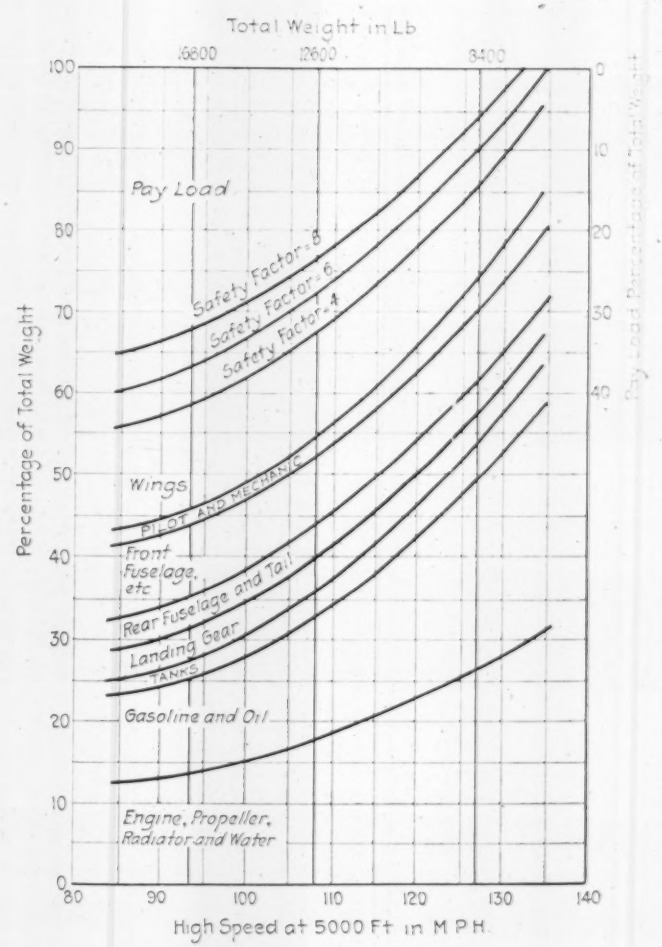

Total Weight in Lb
6800 12600 8400
100 90 80 70 60 50 40 30 20 10 0
Percentage of Total Weight
Pay Load
Safety Factor = 8
Safety Factor = 6
Safety Factor = 4
Wings
Pilot and Mechanic
Front Fuselage, etc
Rear Fuselage and Tail
Landing Gear
Tanks
Gasoline and Oil
Engine, Propeller, Radiator and Water
0 10 20 30 40
Pay Load Percentage of Total Weight
80 90 100 110 120 130 140
High Speed at 5000 Ft in M.P.H.

FIG. 5 VARIATION OF WEIGHT DIVISION WITH SPEED—840-HP. AIRPLANE

(Two Liberty engines, constant minimum speed, 57 m.p.h.; 4 hr. duration wing loading, 10 lb. per sq. ft.)

not complete. However, were it even doubled it would only increase the total cost 3.4 per cent, or, if trebled, 6.8 per cent, so the error is evidently within reasonable limits. It also appears reasonable to assume that this slight increase could be offset by certain economies possible under private operation.

The report of the Air Mail Service for the twelve months ending June 30, 1921, shows the average cost of operating its Liberty 420-hp.-engined airplanes to have been $71.13 per hour of flight.[1] Fig. 7 shows graphically the actual division of this cost over the various items. In estimating cost of operation, in the absence of other data, the assumption has been made that the Air Mail figure is a fair average for 420-hp. machines and that it will vary directly with the engine horsepower.

Operating Cost vs. Duration

We have heard some mention of operating airplanes through from New York to Chicago without an intermediate stop. This distance is about 700 miles in a straight line or 908 miles on the Pennsylvania Railroad. Along the course taken by an airplane it would be 750 to 800 miles owing to the impracticability of flying in a dead, straight line. The great increase in cost of making this flight by eliminating the intermediate stop will be immediately evident from Fig. 8. This figure shows that the operating cost per pound-mile or passenger-mile increases gradually with the duration or distance up to about 4 or 5 hours or 432 to 540 miles. Beyond this the curve takes a rapid upward turn and the cost of operating machines of over 6 hours' duration becomes prohibitive.

If we assume a 420-hp. airplane of the type described under the caption of Fig. 8, having 4 hours' duration and factor of safety of 6, the cost of operation becomes about 0.035 cent per pound-mile. Increasing this duration to 6 hours raises the cost to 0.049 cent or 40 per cent. Doubling the duration, to safely make the New York-Chicago flight without a stop, raises the operating cost to 0.086 cent per pound-mile, an increase of 146 per cent. The general conclusion to be drawn is that commercial airplanes of this size should not be designed for over 4 or 5 hours' duration. Considering now Fig. 9 for larger machines, this effect is more pronounced and it becomes advisable to keep the designed duration even below 4 hours, where possible.

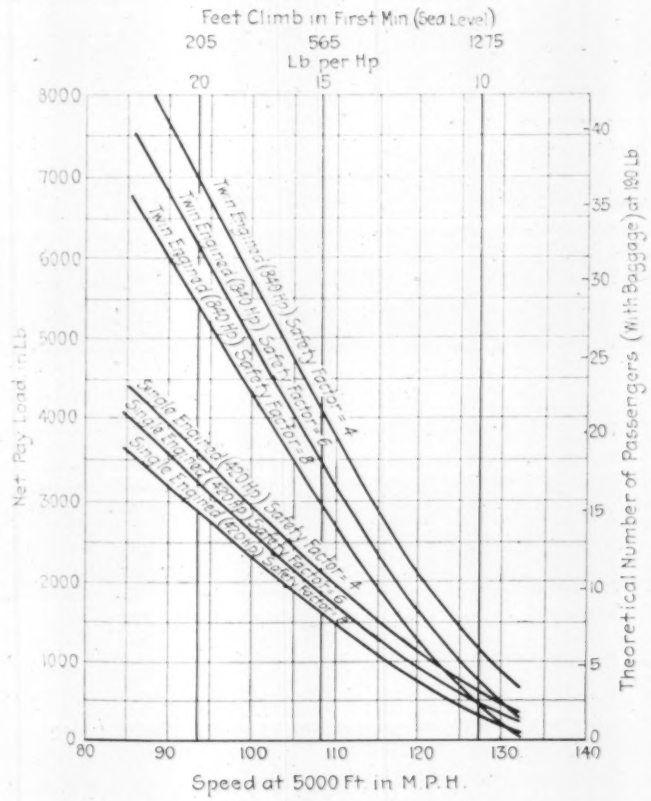

Feet Climb in First Min (Sea Level)
205
565
1275
Lb per Hp
20
15
10
Net Pay Load in Lb
Theoretical Number of Passengers (With Baggage) at 190 Lb
Twin Engined (840 Hp) Safety Factor = 4
Twin Engined (840 Hp) Safety Factor = 6
Twin Engined (840 Hp) Safety Factor = 8
Single Engined (420 Hp) Safety Factor = 4
Single Engined (420 Hp) Safety Factor = 6
Single Engined (420 Hp) Safety Factor = 8
Speed at 5000 Ft in M.P.H.

FIG. 6 VARIATION OF NET PAY LOAD WITH SPEED
(Series of single and twin Liberty-engined airplanes, constant minimum speed 57 m.p.h.; duration, 4 hr.; wing loading, 10 lb. per sq. ft.)

[1] More recent data, which have become available since the study was made, show this figure to have decreased with continued operation.

FIG. 7 DIVISION OF THE OPERATING DOLLAR
(U. S. Air Mail Service for twelve months ending June 30, 1921.)

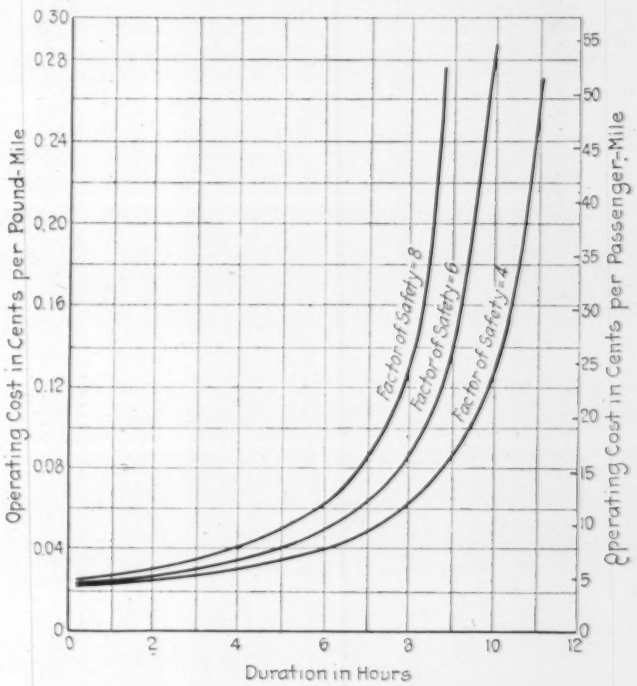

Operating Cost in Cents per Pound-Mile
Operating Cost in Cents per Passenger-Mile
Factor of Safety = 8
Factor of Safety = 6
Factor of Safety = 4
Duration in Hours

FIG. 8 VARIATION OF COST WITH DURATION—420-HP. AIRPLANE
(One 420-hp. Liberty engine; total weight, 6300 lb.; wing area, 630 sq. ft. high speed, 108 m.p.h. at 5000 ft.; minimum speed, 57 m.p.h—10 lb. per sq. ft.; climb from sea level, 565 ft. in first min.)

Operating Cost vs. Factor of Safety

The importance of keeping the factor of safety as low as the conditions warrant is also very evident. Considering Fig. 8 again and increasing from 6 to 8 the factor of safety of the 420-hp., 4-hour-duration machine, the operating cost rises from 0.035 to 0.041 cent per pound-mile or 17 per cent. With the larger machine about the same increase takes place. However, the greater stability and lower maneuverability of the larger airplane permits some slight reduction of the factor of safety. In either case the necessity of keeping factors of safety within limits is apparent.

Operating Cost vs. Speed, Climb, and Reserve Horsepower

The effects on operating cost of speed, climb, and reserve horsepower are considered together, as these factors are inseparable if the low or landing speed remains constant. As landing speed is usually fixed by ground conditions, etc., there appears to be no reason for considering these variations separately. Fig. 10 shows the variation of climb and cost with speed, power loading, and reserve horsepower for two series of freight airplanes. Speeds have been taken as at 5000 ft. altitude to provide a better comparison, as commercial flying will take place at altitudes close to this for safety reasons. With supercharged engines, however, higher altitudes will probably be used because of the higher speeds thus made obtainable.

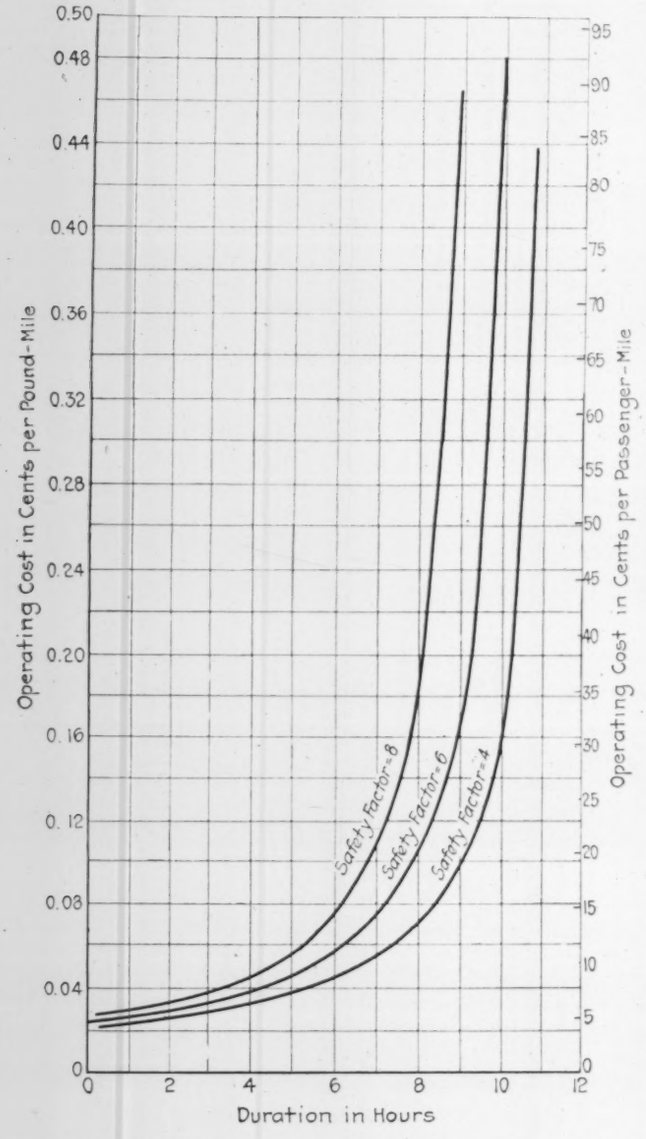


Fig. 9 Variation of Cost with Duration—840-Hp. Airplane

(Two 420-hp. Liberty engines, 840 hp.; total weight, 12,600 lb.; wing area, 1260 sq. ft.; high speed, 108 m.p.h. at 5000 ft.; minimum speed, 57 m.p.h.—10 lb. per sq. ft.; climb from sea level, 565 ft. in first min.)

Starting from the lower speeds the cost of operation rises steadily until about 105 or 110 m.p.h. is reached when a rapid upturn takes place, carrying this cost to prohibitive values for speeds above 110 or 115 m.p.h. The effect of factor of safety is also noticeable, particularly at the higher speeds. It is important to note here that of all the curves presented in this paper, Figs. 10 and 11 are the most susceptible to modification when applied to radically different types of design. At the same time they may be taken to apply to present-day airplanes of good, conventional design. The only effect of extremely fine lines would be to raise slightly the critical speed at which the cost becomes prohibitive. Against this possibility of refinement must be balanced the fact that the large fuselages necessary for commercial work place a limit on the reduction of head resistance.

In determining the best operating speed a compromise must be effected between low speed with its low reserve horsepower and high speed with its high cost. At the top of Fig. 10 a scale of reserve horsepower will be noted. This was obtained by plotting climb against power loading and extending the curve down to the point where climb became negligible. The speed at which this occurred was taken as the speed corresponding to the machine at the lower end of the series and having no reserve horsepower. The reserve horsepower scale was then laid off from the loading. This scale is approximate because, among other items, it does not take propeller efficiency into consideration. However, it is of value in furnishing a fair measure of what can be done with reduced engine speeds.

The necessity of keeping reserve horsepower down to reasonable limits is immediately evident. Experience has shown that an initial climbing speed of 400 to 500 ft. in the first minute is about the lowest consistent with safety, for operation from sea-level territory. To provide a basis for comparison an initial climb of 500 ft. in the first minute is assumed to be satisfactory. This gives a reserve horsepower of about 58 per cent and a high speed at 5000 ft. of 106 m.p.h. while the operating cost for safety factor of 6 is 0.032 cent per pound-mile for a 420-hp. machine or 0.034 cent per pound-mile for the 840-hp. machine.

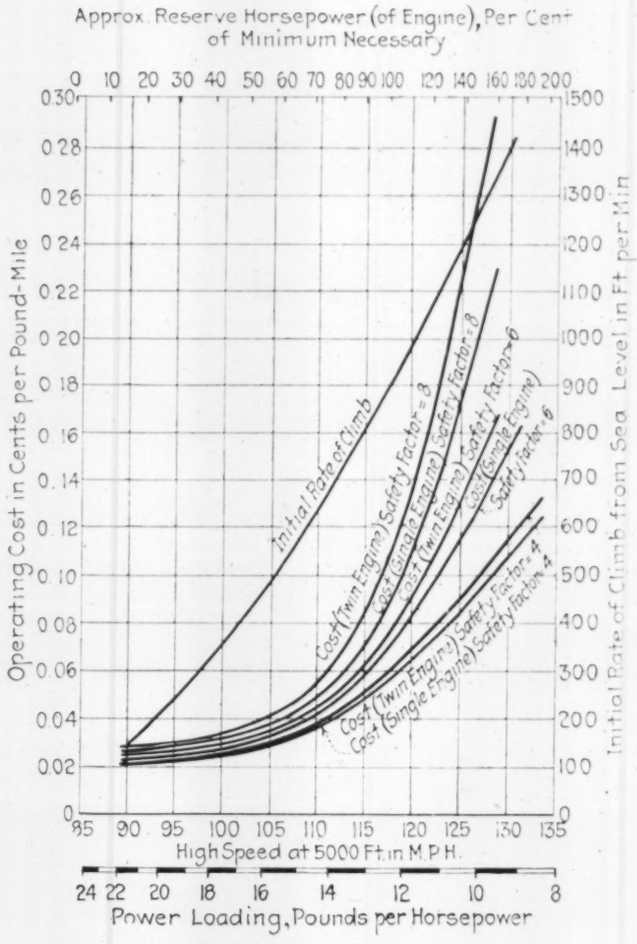

Approx. Reserve Horsepower (of Engine), Per Cent of Minimum Necessary
Operating Cost in Cents per Pound-Mile
Initial Rate of Climb from Sea Level in Ft. per Min.
Initial Rate of Climb
Cost (Twin Engine) Safety Factor=8
Cost (Single Engine) Safety Factor=8
Cost (Twin Engine) Safety Factor=6
Cost (Single Engine) Safety Factor=6
Cost (Twin Engine) Safety Factor=4
Cost (Single Engine) Safety Factor=4
High Speed at 5000 Ft. in M.P.H.
Power Loading, Pounds per Horsepower

Fig. 10 Variation of Cost and Climb with Speed and Reserve Horsepower

(Series of single and twin Liberty-engined freight airplanes of constant minimum speed of 57 m.p.h.—10 lb. per sq. ft.; duration, 4 hr.)

Flying on One out of Two Engines. Let us assume that the twin-engined machine is required to fly on one of its engines. Reserve propeller horsepower of at least 100 per cent must be provided. With only one engine running the lower speed will cause a drop in

propeller efficiency from 80 per cent to about 70 or 75 per cent. Taking a propeller efficiency of 72.5 per cent, the reserve horsepower required becomes: $(80 \times 100) \div 72.5 = 110$ per cent. Consulting Fig. 10 we find that climb has increased to 980 ft. in the first minute, speed at 5000 ft. has increased to 120 m.p.h., and cost of operation to 0.089 cent per pound-mile. In other words, the machine under consideration has been taken right out of the commercial class and put into the military-fighter class, while its cost of operation has increased to 162 per cent over that of a rational commercial design.

Even assuming the possibility of maintaining efficiency at 80 per cent by using a variable-pitch propeller, the increase in operating cost is still 118 per cent over normal. A study of Fig. 11 will show that the same results are obtained with the passenger machines. These figures should be sufficient to demonstrate the utter impracticability of the requirement that twin-engined machines be designed to fly on one of their engines. It seems safe to say that the prohibitive operating cost resulting from enforcement of this requirement would be sufficient to eliminate the possibility of developing commercial airplane transportation.

Flying on Two out of Three Engines. If a three-engined machine is required to fly on two of its engines a minimum reserve propeller horsepower of 50 per cent is necessary. Assuming drop in propeller efficiency from 80 per cent to 75 per cent the required reserve horsepower of the engine becomes: $(80 \times 50) \div 75 = 53.3$ per cent. This is about the reserve required to provide the climb necessary for safe operation. It is thus evident that the requirement of flying on two out of three engines is reasonable and practicable.

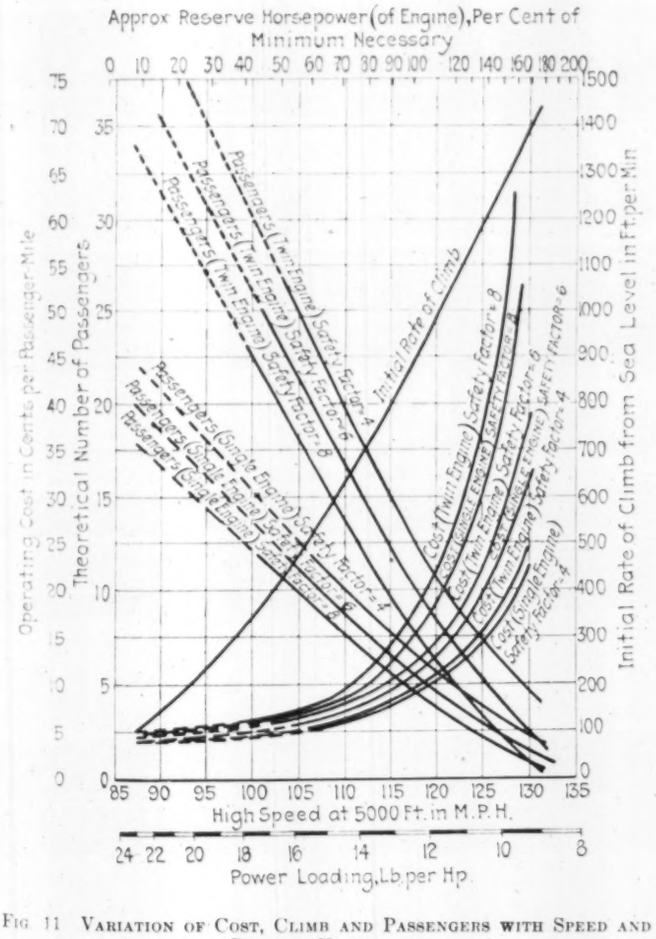

Approx Reserve Horsepower (of Engine), Per Cent of Minimum Necessary
Theoretical Number of Passengers
Operating Cost in Cents per Passenger-Mile
Initial Rate of Climb from Sea Level in Ft. per Min
High Speed at 5000 Ft. in M.P.H.
Power Loading, Lb. per Hp.
Passengers (Twin-Engine) Safety Factor=8
Passengers (Twin-Engine) Safety Factor=6
Passengers (Twin-Engine) Safety Factor=4
Passengers (Single-Engine) Safety Factor=8
Passengers (Single-Engine) Safety Factor=6
Passengers (Single-Engine) Safety Factor=4
Initial Rate of Climb
Cost (Twin-Engine) Safety Factor=8
Cost (Twin-Engine) Safety Factor=6
Cost (Twin-Engine) Safety Factor=4
Cost (Single-Engine) Safety Factor=8
Cost (Single-Engine) Safety Factor=6
Cost (Single-Engine) Safety Factor=4

FIG. 11 VARIATION OF COST, CLIMB AND PASSENGERS WITH SPEED AND RESERVE HORSEPOWER

(Series of single and twin Liberty-engined passenger airplanes, constant minimum speed, 57 m.p.h.—10 lb. per sq. ft.; duration, 4 hr. Dotted curves indicate capacity above practical limit. Passengers calculated at 190 lb. each including baggage.)

Aside from landing speed the one element of paramount importance in determining the safety of commercial aircraft is its

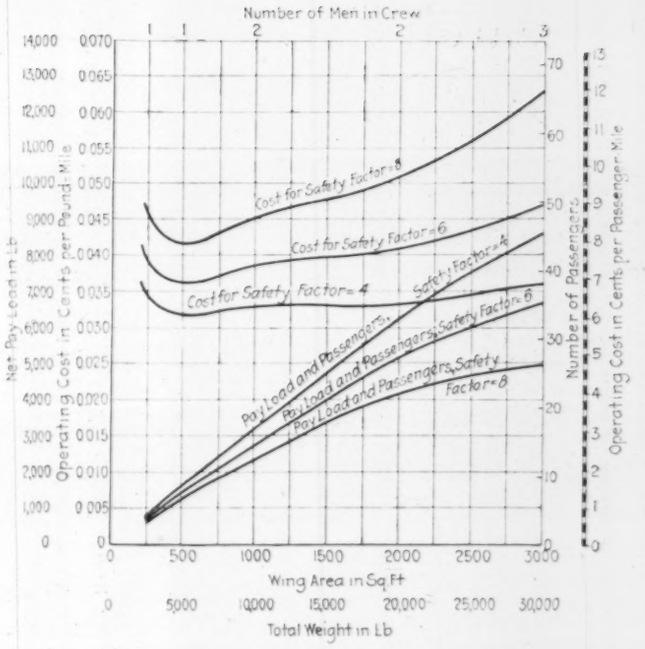

Number of Men in Crew
Net Pay Load in Lb.
Operating Cost in Cents per Pound-Mile
Number of Passengers
Operating Cost in Cents per Passenger-Mile
Cost for Safety Factor=8
Cost for Safety Factor=6
Cost for Safety Factor=4
Pay Load and Passengers, Safety Factor=8
Pay Load and Passengers, Safety Factor=6
Pay Load and Passengers, Safety Factor=4
Wing Area in Sq. Ft.
Total Weight in Lb.

FIG. 12 VARIATION OF COST, PAY LOAD, AND PASSENGERS WITH SIZE

(Series of Airplanes loaded 10 lb. per sq. ft.; 15 lb. per hp.; duration, 4 hr., minimum speed 57 m.p.h.; high speed, 108 m.p.h. at 5000 ft.; climb from sea level 565 ft. in first min. Passengers calculated at 190 lb. each including baggage.)

climbing speed, this being a measure of reserve horsepower. As an initial climb rate of 400 to 500 ft. in the first minute has been found to be consistent with safety, no reason for increasing this is apparent. If, therefore, we are to write safety requirements for performance of commercial airplanes, the most logical measure to use would be their climbing speed.

OPERATING COST VS. SIZE OF MACHINE

The curves of Fig. 12 are based upon calculations of machines of 250, 500, 1000, 2000, and 3000 sq. ft. wing area. Some arbitrary assumptions regarding the number of men in the respective crews were necessary and these numbers appear at the top of the graph.

The form of these curves was a surprise to the author, the economical sizes being much lower than he had anticipated. They show marked economy for machines of the type under consideration in the size in which the wing area is about 500 to 600 sq. ft. This economical size would, of course, be changed somewhat were the performance of the series altered. The quick upturn of the cost curves for small sizes of machines is due to the constant allowance for weight of the pilot crowding out a larger percentage of the net pay load. The slight "hump" in the same curves at about 1000 sq. ft. area is due to the allowance for a crew of two, while the gradual rise toward the larger machines is due to the increased structural weight of the wings and to the allowance of three men for the crew. This increase can be modified somewhat by further refinement in design but an allowance corresponding to existing practice *has already been made*. To avoid the very laborious work of estimating in detail the investment and operating cost for each size the following assumptions have been made: (1) That the Air Mail cost applied directly to the 420-hp., 630-sq-ft. size; and (2) that the operating cost for other sizes varied directly with the size. In considering the question of size, some preference should be given to machines having more than one pilot. The added safety thus obtained makes it worth while to sacrifice some possible savings by reducing size.

OPERATION COST VS. LANDING SPEED

No detailed study of the effect upon operating cost of varying the landing speed or low speed has been included. Landing speed being practically fixed by the field conditions to be met, very little variation is permissible when the design is being made. Consequently it appeared unnecessary to go into this effect as thoroughly as into other features of performance.

(*Continued on page 849*)

Research Fundamental for Hudson Tunnel Design

Design of Longest Vehicular Tunnel Requires Exhaustive Research to Determine Physiological Effects of Exhaust Gases and to Proportion Ducts and Orifices in Ventilation System

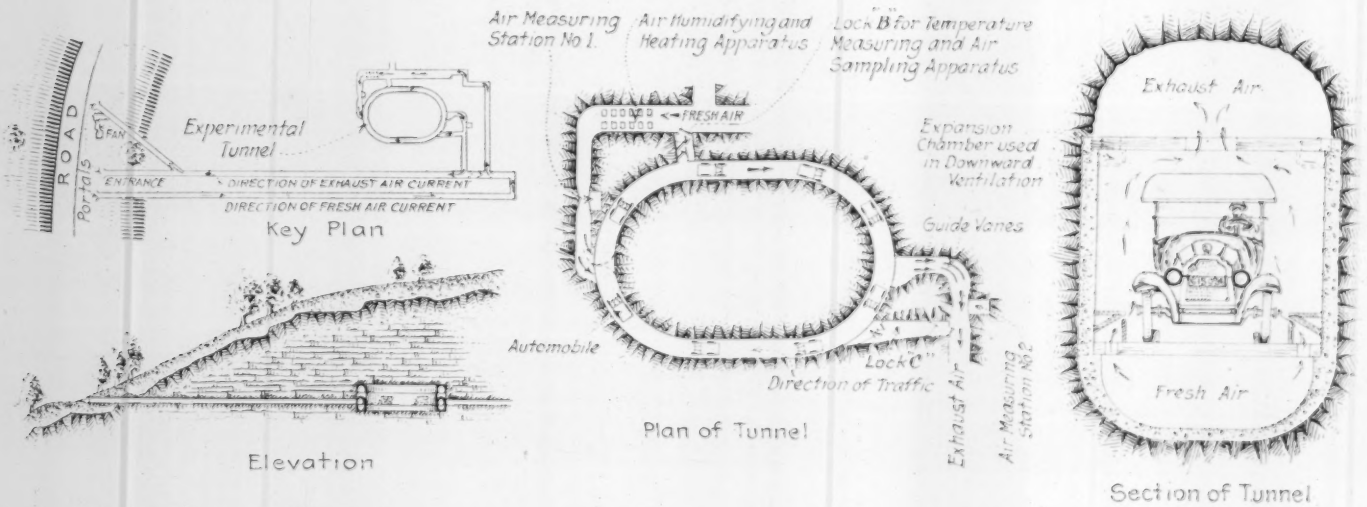
THE entire development of modern industry with its great achievements in opening up new fields and basically revolutionizing old ones, has shown that the new ways of applying materials have contributed mightily to the changes in modern economics, even more so perhaps than the three formerly well-recognized factors of production: land, labor and capital. Further, modern engineering has shown the absolute need of "knowing how" when an attempt is made to accomplish anything vastly bigger in size than has ever been tried before. Bridges have been built from time immemorial. Iron (latterly, steel) bridges have been common for a century, and yet failure was the result of the first two attempts at building the Quebec Bridge, an unprecedentedly huge structure. Knowledge of the behavior of such enormous masses of material was lacking. There have been many other instances in which an increase in size unaccompanied by accurate knowledge has brought disaster. We recall the early failures of ore-carrying steel boats on the Great Lakes, which continued until proper ways of bracing and reinforcing them were found. There are many other such instances well known to the engineering profession.

In engineering design a lack of knowledge can be met in two ways. One, applied whenever possible, is to introduce what are known as factors of safety. A more proper designation might be factors of doubt or of ignorance. Another way is to analyze the unknown conditions and determine the facts relating to them.

The method of handling the ventilation problem in the projected Interstate Tunnel under the Hudson River connecting New York and Jersey City is a fine example of the modern way of securing by rigorous research the fundamental facts for the solution of a big engineering problem, difficult not only because of the unusual size of the undertaking but because there was a comparative lack of exact information as to the technical factors involved.

In the first place, the tunnel is much larger than anything of the kind ever undertaken before. The only vehicular tunnels even approximately comparable to the Hudson River Tunnel are the Blackwall and the Rotherhithe tunnels under the Thames River in London. These have, however, an under-river length of only 1221 and 1570 ft., respectively, and carry a traffic of less than 100 motor vehicles each per hour, whereas the Hudson River Tunnel, to be 8300 ft. long, is designed to handle in excess of 2000 motor vehicles per hour, or more than 20 times as many as the London tunnels, where, it may be stated, atmospheric conditions are reported to be bad at times.

There were three elements to be determined before a comprehensive design of the ventilation system could be worked out. First, it became necessary to determine the amount and composition of exhaust gases from the motor-driven vehicles which were to pass through the tunnel at a known rate. The next problem was to find out what quantity, or rather percentage, of these exhaust gases in air would be harmful to persons spending the time in the tunnel necessary to pass from one end to the other, taking into consideration various possible delays. With these two factors known, it became a simple mathematical problem to find out how much fresh air must be introduced into the tunnel to produce the necessary dilution and render the exhaust gases harmless. Finally, it was necessary to determine the complete design for adequate ventilation and, to be on the safe side, actually try it out before an irrevocable commitment was made to its use in the actual structure. It was neither an easy nor a simple matter to obtain information on all these factors, but it was obtained, and American engineering may be justly proud that all the tests were carried out in a scientific manner and with a considerable degree of precision in institutions located in this country, an largely with apparatus developed in America.



EXPERIMENTAL TUNNEL CONSTRUCTED IN THE ROOM WORKINGS OF A COAL MINE AT BRUCETON, PA.

A series of tests were carried out at the Pittsburgh Experiment Station of the Bureau of Mines in accordance with the program of the Chief Engineer of the Tunnel Commission. A number of passenger cars and various kinds of trucks and buses were tested both under summer and winter conditions on a level course and over various grades. The exhaust gases were carefully analyzed, and it was found that the percentage of carbon monoxide for all classes of vehicles varies within wide limits and depends on a number of variables. The effect of carburetor adjustment is probably directly or indirectly far greater than that of any other factor. It was also found that because of improper adjustment—something quite common with the average automobile driver—there is an immense waste of gasoline from the resulting excessively rich mixtures.

In the tests the average output of carbon monoxide for each class of motor vehicles under certain conditions was determined, and this together with a knowledge of the vehicle capacity of the tunnel gave

Acknowledgment should be made for the assistance given in the preparation of this article to C. M. Holland, chief engineer, and Ole Singstad, assistant chief engineer, of the Interstate Tunnel Commission.

a fairly clear idea as to the maximum volume of toxic gases with which the ventilating engineer must reckon.

PHYSIOLOGICAL EFFECTS OF EXHAUST GASES

This part of the investigation was carried out at the Laboratory of the Bureau of Mines at Yale University with Yandell Henderson in charge. The Bureau of Mines had had considerable experience in this kind of work as it had already undertaken studies which dealt with the use of traction engines in coal mines, the vitiation of air in small garages and coal mines, and the determination of standards for the vitiation consistent with safety.

Prior to this investigation the standards of allowable air vitiation with carbon monoxide had not been precisely defined. Dr. J. S. Haldane, in England, had investigated the question chiefly with reference to the safety of miners after mine explosions and fires, and his attention had accordingly been directed to the amount of carbon monoxide which would incapacitate or seriously inconvenience a man, rather than to those amounts which are compatible with complete comfort and efficiency.

The simplest way to deal with this question would be to demand that the air in the tunnel be as pure as that of the city streets, with a standard of, say, not more than one part of carbon monoxide in 10,000 parts of air. This standard would not be economical, however.

Carbon monoxide when inhaled produces oxygen deficiency in the body which leads to physiological results that vary with the length of exposure and the concentration of the gas. This latter, it may be stated, is commonly measured and expressed for purposes of ventilation as one or more "parts" of this gas mixed with 10,000 times as much air, one "part" being therefore one-hundredth of one per cent of the atmosphere.

The absorption of carbon monoxide by the hemoglobin of the blood proceeds at first at a very rapid rate but slows down as time goes on, and the more carbon monoxide the blood absorbs the greater becomes the force with which this gas tends to diffuse out again into the air, the condition gradually approaching a state of equilibrium, though it is not certain to what extent it ever reaches it. As a definite quantity for determination may be selected the time required for an attainment of a percentage saturation of one-half the equilibrium values. Thus, in an atmosphere containing two parts of carbon monoxide for which the blood equilibrium is about 28 per cent, the length of time that would be required for the blood to become 14 per cent saturated, and so on for other concentrations and percentages of saturation.

The answer to this question is the principal practical contribution to knowledge that has been made. Experimentally it has been found that the time for attainment of half-equilibrium for persons sitting at rest and breathing concentrations of carbon monoxide up to 7 per cent is never much less than one hour, and what is more, it has been established experimentally and by analysis of reasonable conditions that the vast majority of people who may travel through the tunnel under conditions of actual operation can be safely assumed to fall within these limits.

The method of studying the effects of various concentrations of carbon monoxide which has been found to be the most reliable for establishing standards of permissible vitiation of air is illustrated in Fig. 2, which shows a chamber of 226 cu. ft. capacity. The walls and door of this chamber are made gastight to such an extent that it will hold any concentration of gas for a day without any appreciable loss from diffusion through undiscovered leaks. A small hole in the door allows the hand of the man inside to be thrust out for the withdrawal of blood.

Measured amounts of pure carbon monoxide were introduced into this chamber and in turn the members of the investigating staff and a few other persons spent periods of one hour therein after amounts of carbon monoxide from two to eight, and in one case ten, parts were introduced. While they sat and read most of the time, there were a sufficient number of activities, such as turning on the electric fan, standing up to look out of the window for a moment, opening and closing flasks to take air samples for later analysis, etc., to correspond fairly well with those of the driver of a car. Blood to the amount of 20 or 30 drops was drawn from a finger before the subject entered the chamber and 0.02 cc. were drawn in the middle of the period and at the end, and usually once or twice during the three hours following the subject's leaving the chamber. These blood samples were analyzed for carbon monoxide, in addition to which certain checks were used and other observations taken. Of all signs and tests both in the experiments in the chamber and in other tests, the typical carbon-monoxide or oxygen-deficiency headache proved the most definite and reliable. It is a distinctly localized pain, usually frontal, throbbing, intensified by lying down or by exertion, and accompanied by certain effects, such as nausea, etc.

As a result of these tests it was found that if at any point the concentration exceeds six parts of carbon monoxide in 10,000 of air, men doing hard work for even a short time will be unfavorably affected. A study of the traffic conditions expected to obtain in the tunnel has shown that even slow-moving trucks, allowing for all possible ordinary delays, will pass through the tunnel in less than 45 min. and a degree of concentration has been determined which will provide not only complete safety but also an assurance of freedom from disagreeable effects due to the presence of carbon monoxide. There are, of course, other features of tunnel ventilation, for example, wind velocity, moisture, temperature, etc.,

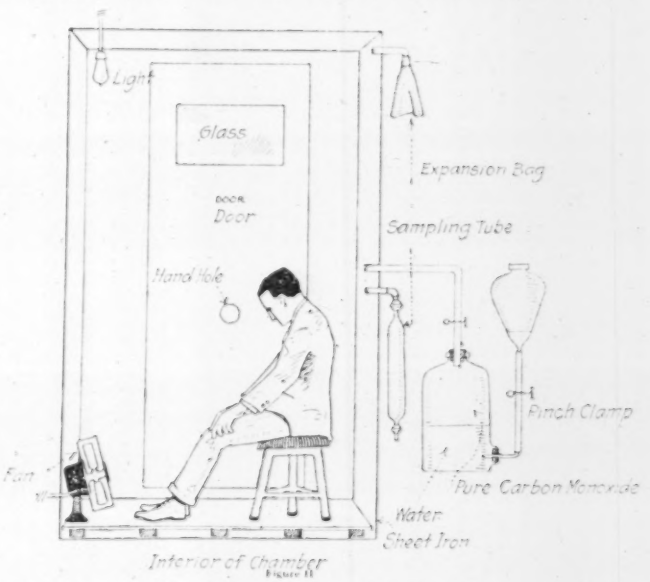


FIG. 2 CHAMBER OF 226 CU. FT. CAPACITY USED IN STUDYING EFFECTS OF VARIOUS CONCENTRATIONS OF CARBON MONOXIDE

which have not been specially investigated in the present instance, but enough is known about them to permit intelligent design of the ventilation apparatus.

One is strongly impressed with the thoroughness of the tests carried out in this connection. For example, in addition to tests in the small chamber described above which involved exact but rather artificial conditions, another series of tests were carried out with actual exhaust gas and under conditions as near as possible to those that will be encountered in the tunnel when completed. For this purpose a hip-roofed brick building 30 ft. by 30 ft. with walls 12 ft. high was erected. Its cubic capacity was approximately 12,000 cu. ft. of air, which is about the volume of the vehicular tunnel required for two cars when the traffic is active. A Ford car was installed near the middle of this chamber with a dynamometer arrangement that permitted the engine of the car to run at a fair load and to expend the power in mixing the air in the chamber.

In this chamber groups of a dozen or more persons at a time sat or moved about for periods of one hour. In addition to the staff of this investigation a number of students of the Yale Medical School, both men and women, served as subjects. After the tests the general condition and feeling of the subjects, particularly the occurrence or absence of headache, were noted and other observations taken, proper gas analysis being carried on all the time. A few observations were also made on two horses, and dogs were subjected to high concentrations of gases, various gases besides carbon monoxide and exhaust gas being used for this purpose in order to obtain as extensive results as possible.

THE MECHANISM OF VENTILATION OF THE TUNNEL

With the completion of tests at the Bureau of Mines Laboratory in Pittsburgh and the Physiological Laboratory at Yale University, the tunnel engineers had a fairly clear idea as to the problem that lay before them. From the number of cars for which the tunnel was designed and the volume and composition of gases found in the exhaust, the amount of toxic gases was known, while the Yale University tests established a standard for the permissible content of carbon monoxide and similar constituents in air. From this it was quite simple to determine the amounts of air per unit of time to be supplied to the tunnel in order to maintain the proper ventilation. In a smaller installation this would have ended the necessity for further investigation. In the present case, however, it became necessary to go a step further and determine such things as the coefficient of friction for flow of air in concrete ducts; the laws governing the flow of air in concrete ducts of uniform cross-section with the air leaving or entering in uniform quantities at uniform intervals; and finally the power losses in bends or elbows in concrete air ducts. This part of the work was conducted partly at the Bureau of Mines and partly in a special experimental plant at the University of Illinois, Urbana, Ill., under the direction of the Chief Engineer of the Commission or his representatives.

Extensive tests carried out at the University of Illinois gave sufficient information as to the behavior of the air under the various desired conditions and permitted the derivation of equations for blowing or exhausting air through a duct in uniform quantities at uniform intervals. These made it possible to compute the air horsepower required.

With the conclusion of these tests, what might be called the scientific foundations for the design were laid down. In view of its unusual size and the novelty of some of the elements involved, it was obviously desirable, if possible, to test out the relative merits of various methods of transverse or distributive ventilation, introducing fresh air through the bottom duct and exhausting through the top duct, and vice versa. Experiments were accordingly conducted in an experimental tunnel constructed in the room workings of a coal mine at Bruceton, Pa. (Fig. 2). The reason for constructing the experimental tunnel underground was to secure a location that would be free from atmospheric disturbances and to obtain data on the flow of heat through the walls of the tunnel.

The tunnel had a driveway 8 ft. high by 9 ft. wide with continuous air ducts above the ceiling and below the roadway. The ducts under the roadway and the walls of the driveway were of concrete construction. The tunnel was oval in plan, giving a road way length of 400 ft.

The quantity of air was measured before entering the tunnel ducts and on leaving at two specially constructed air-measuring stations in the mine passages. Samples of the air were taken at various points in the tunnel driveway and thermocouples were installed to obtain the temperature of the incoming and outgoing air, the temperature of the tunnel atmosphere, and the rate of flow of heat through the tunnel walls. Smoke observations were made by means of an optical instrument and by the Ringlemann chart. Physiological data were taken by various means.

Cars were run in the tunnel so as to give conditions as nearly as possible approaching those that would prevail in the Hudson tunnel and it was found that smoke in the tunnel atmosphere under ordinary operating conditions was not dense enough to interfere in any way with driving or comfort. It was also found that ventilating upward with openings over the center of the roadway gave better results than exhausting through continuous slots in expansion chambers located just under the ceiling at the two sides over the driveway. In downward ventilation better results were obtained by introducing the fresh air horizontally than by introducing it at an angle of about 45 deg. through the expansion chambers. The tests demonstrated that with upward ventilation the exhaust gases crossed the breathing plane of persons using the tunnel but once, while with downward ventilation they crossed this plane twice. The chemical analyses of the tunnel atmosphere also showed a lower concentration of carbon monoxide at the breathing plane with the upward than with the downward ventilation. It was therefore concluded that transverse upward ventilation is the proper method.

Experiments in the concrete model duct and elbows, together with the experiments in the experimental tunnel under actual operating conditions, have given sufficient data to determine the power required to operate the fans for ventilating the tunnel and indicate that the mechanical ventilation of the tunnel as planned is assured of success.

The general plan of ventilation adopted is as follows: Blower fans located in buildings over the four shafts will supply the required amount of fresh air to the main fresh-air duct located under the tunnel roadway. The air will then pass through flues to continuous expansion chambers, one on each side of the roadway, thence through a continuous slot to the roadway. The air remains in the tunnel an average of $1^1/_2$ min., during which time it slowly ascends from the roadway to the ceiling. Exhaust fans located in the same buildings with the blower fans will draw the vitiated air through ports in the ceiling and thence through the upper duct, delivering it through stacks to the outer atmosphere. In this way fresh air will be supplied in the proper amount to all points throughout the tunnel. There will be no discomfort or danger from high-velocity air currents and the exhaust gases will be quickly diluted and removed.

There is one feature in this work which deserves mention and that is the clear realization of the fundamental idea that the safety and even comfort of those riding in the tunnel must be carefully considered.

Smoke and noxious gases, though of different character, have always been present in railroad tunnels, especially those of considerable length, and have made travel in them anything but pleasant. When these tunnels were built, however, the idea of caring for the comfort of passengers to the extent of providing them at all times with clean air had not yet been conceived. Those who had to travel could not avoid riding through the tunnels, and whatever discomfort they experienced did not seem to affect the business of the railroad companies. Had the Hudson Tunnel been built 25 years ago perhaps the same conditions would have prevailed, and the question of ventilation would have been handled in some hurried and ineffective fashion. It is, therefore, with sincere pleasure that one records an enlightened attitude toward the design of public utilities in which an earnest effort is made to provide decent atmospheric conditions.

University Research

From an engineer's point of view it is essential that the universities keep *instruction* as their great work—instruction of matriculated students and instruction of the far greater public outside the cloistered walls.

There are two very good reasons why the faculty of a technical school should engage in research. In the first place, a true teacher is also a student—he is curious about the unknown. In the second place, the schools and their faculties must advance in order to hold their jobs. Abstruse science of yesterday is commonplace technology of today. So if there were not more new things constantly discovered, the engineering and scientific colleges would quickly become trade schools.

It seems agreed that investigation is necessary to the well-being of our schools. But what kind? We believe that the true scientific researcher does not select his problem from a scrap pile. But with a background made up of thorough familiarity with the literature of his specialty, an acquaintance with the principal workers in the field and the useful applications which have so far been made, he selects one of the broader problems that remain to be solved and attacks the matter with a quite disinterested perspective. He throws all the resources he can bring to bear into the search, and in time, perhaps years, reaches a solution—or at any rate it becomes known that he is very well informed in that particular branch. Then with the advantage of this position, he is able to give the public the maximum amount of seasoned, correct advice with the least amount of distraction from his ordered routine. And that's the only kind of advice he will attempt to give. It is more than doubtful that this eminent and influential position could ever be reached by a university faculty that devoted itself to commercial research—which is time-consuming, but rarely broad and never disinterested. (*Chemical and Metallurgical Engineering*, vol. 27, no. 15, Oct. 11, 1922, p. 725)

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

The New Paris High-Pressure High-Temperature Central Station

DURING the past few months the technical press in the power field has given much attention to the new Gennevilliers central station which is now in partial operation carrying a portion of the electrical load of the city of Paris. This station, which will have an ultimate capacity of 320,000 kw., is designed with the ruling idea that economy in fuel is imperative. To achieve this the French engineers decided on turbines operating at a pressure of 313 lb. gage and with a superheat of 280 deg. fahr. at the throttle. The design of the plant is accordingly novel and interesting.

A complete description of the plant by Col. Ernest Mercier, was given in a pamphlet published this year by the *Revue Industrielle* of Paris. The illustrations on this and following pages are taken from this account. Other descriptions of this station are given in in the following journals:

The Engineer, vol. 134, nos. 3480, 3481 and 3482, Sept. 8, 15, 22, 1922, pp. 242–243, 270–272, 294.
Génie Civil, vol. 81, no. 1, July 1, 1922, pp. 1–13.
Industrie Electrique, vol. 31, no. 722, July 25, 1922, pp. 265–276.
Power, vol. 56, nos. 5 and 7, Aug. 1 and 15, 1922, pp. 156–162, 232–236.
Electrical World, vol. 80, no. 6, Aug. 5, 1922, pp. 264–270.

Costs

In the pamphlet referred to, Colonel Mercier, who was responsible for the design of the plant, gives the following statement as to costs:

Due to the thorough study of all questions and due to the rigorous supervision of all expenditures, including the value of the grounds and that part of the financing charges attributable to the generating station, the cost of the station, based upon the first 200,000 kw. installed, will be slightly under 600 francs per installed kilowatt.

After the installation of units Nos. 6 and 7, the total power then being 280,000 kw., the cost per installed kilowatt will have decreased to 530 francs. This latter figure is based upon the supposition that the price of land, the cost of extensions, docks and labor remain the same as at present, and that the construction of the station, as it is actually built, will allow the placing of the sixth unit without any addition to the present structure.

The goal was to construct a station at the prewar price, regardless of the new and expensive apparatus decided upon.

The following facts regarding the station are taken from the account given in *Power*, of August 1, 1922.

BOILER-ROOM EQUIPMENT

	Double-ended Stirling	Single-ended B. & W.	Total
Number of boilers to be installed at once	5	10	15
Ultimate number of boilers, various possibilities	11	10	21
	8	16	24
	5	22	27
Maximum allowable steam pressure, lb. per sq. in.			355
Maximum total steam temperature, deg. fahr.			752

Boiler Dimensions and Characteristics

	Stirling	Babcock & Wilcox
Heating surface per boiler, sq. ft.	22,600	14,300
Superheater surface, sq. ft.	10,764	8,190
Economizer surface, sq. ft.	12,915	8,617
Air-preheater surface, sq. ft.	19,350	12,060
Overall dimensions:		
Width of face	34 ft., 10 in.	35 ft., 11 in.
Length	37 ft., 9 in.	20 ft., 3 in.
Height from boiler-room floor to C.L. of highest steam drum	28 ft., 7 in.	21 ft., 3 in.
Volume of water at normal water level, cu. ft.	2,860	1,288
Volume of steam at normal water level, cu. ft.	705	583
Ratio volume of water to volume of steam	4.05	2.21
Volume of water per sq. ft. of heating surface, cu. ft.	0.127	0.09
Steam guarantees:		
Normal steaming rate, lb. per hour	132,000	88,000
Lb. per hour per sq. ft. heating surface (normal)	5.85	6.15
Maximum two-hour rate, lb. per hour	176,000	116,000
Lb. per hr. per sq. ft. heating surface (maximum)	7.79	8.12

Grate Characteristics

Stirling boilers: Riley underfeed 36-retort mechanical stoker, in two sections of 18 retorts each, fed from two firing aisles, and discharging the ash in the center.
Total grate surface per boiler, 660 sq. ft.
Babcock and Wilcox boilers: B. & W. chain-grate stokers, in four sections, each 15 ft. long by 6 ft. 7 in. wide, equipped for forced draft.
Total grate surface per boiler, 394 sq. ft.

DRAFT EQUIPMENT AND COMBUSTION GUARANTEES

A. Stacks:
Number and type of stacks: 6 convergent-divergent, Pratt type.
3 stacks serving the Stirling boilers, 3 the B. & W.
1 stack for 2 Stirling or 4 B. & W.

Stack dimensions:	Stirling Boilers	B. & W. Boilers
Height (total)	121 ft.	121 ft.
Base (rectangular)	13 ft., 9 in. x 12 ft., 4 in.	15 ft., 1 in. x 13 ft., 9 in.
Throat diameter	6 ft., 3 in.	7 ft., 3 in.

B. Induced-draft fans:
Number of fans per stack: 2
Drive: Direct-current, adjustable-speed motors
Rated capacity of motors: On Stirling boiler stacks ..... 120 hp.
On B. & W. boiler stacks ..... 150 hp.

Guarantees:
Assuming: Lower heating value of coal, 12,600 B.t.u. per lb. Temperature of outside air, 61 deg. fahr. Barometric pressure, standard. Temperature of gases entering the induced-draft fans, 284 deg. fahr. CO_2 content of gases entering the induced-draft fans, 11 per cent. Forced-draft fans operating at their normal rate.

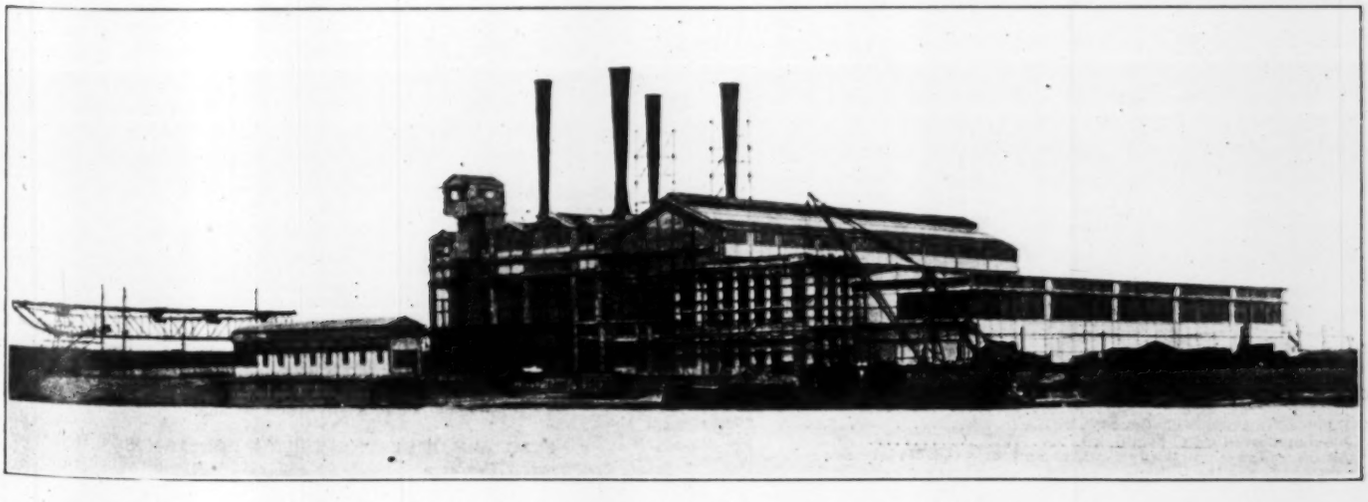


FIG. 1 THE GENNEVILLIERS STATION. VIEW TAKEN FROM THE SEINE, MAY, 1922

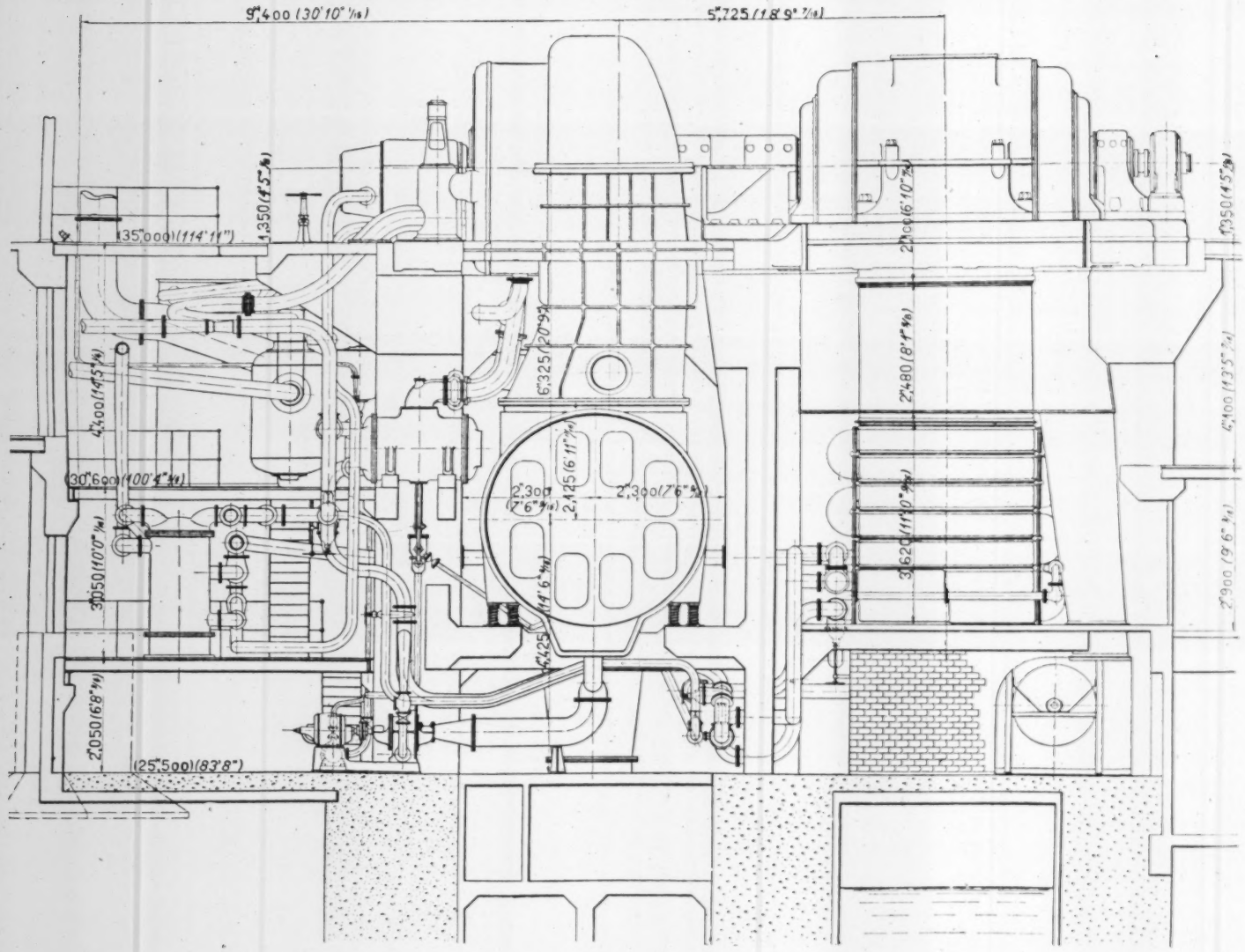


FIG. 2 40,000-KW. TURBO-GENERATOR, ELEVATION

	Stirling-Boiler Stack Serving 2 Boilers or 1,320 Sq. Ft. of Grate			B. & W.-Boiler Stack Serving 4 Boilers or 1,576 Sq. Ft. of Grate		
Draft at base of stack:	Natural	0.9 in.	1.97 in.	Natural	0.9 in.	1.97 in.
Combustion rate:						
Lb. per hour	23,100	31,900	46,200	30,400	41,400	60,700
Lb. per hour per sq. ft. of grate	17.5	24.2	35	19.3	26.3	38.5
Speed of fans, r.p.m.						
No. 1	0	335	430	0	305	385
No. 2	0	0	430	0	0	385
Power consumption of fans:						
No. 1, hp.	0	44	88	0	55	110
No. 2, hp.	0	0	88	0	0	110

Under the foregoing conditions, but with the forced-draft fans shut down, the induced-draft equipment alone will supply a draft of 2.36 in. with the expenditure of 170 hp. on each of the B. & W. stack motors, and 132 hp. on each of the Stirling stack motors.

C. Forced-draft fans:	Stirling Boiler			B. & W. Boiler		
Number of fans per boiler	4			2		
Drive	Direct-current adjustable-speed motors					
Rated capacity of motors	60 hp.			80 hp.		
Fan characteristics:	Output, cu. ft. per hr.	Power cons'n, hp.	Speed, r.p.m.	Output, cu. ft. per hr	Power cons'n, hp.	Speed, r.p.m.
Normal rate—5.9 in. draft.	1,760,000	43	870	2,380,000	58	745
Overload —7.1 in. draft.	1,980,000	60	955	2,650,000	80	820

TURBINE-ROOM EQUIPMENT

Number of Generating Units:	
In present plant	5
Ultimate number of units	8
Capacity of Generating Units at 80 per cent Power Factor:	
Most efficient load, kw	30,000
Full load (maximum continuous), kw	40,000
Maximum overload (2 hours), kw	45,000
All the units are practically identical, and the rotors are interchangeable.	
Characteristics of the Units:	
Speed, r.p.m.	1,500
Frequency, cycles	50
Terminal voltage	6,000
Throttle pressure, lb	313
Total steam temperature, deg. fahr.	705

Type of Turbines: Simple impulse Zoelly type, straight single-flow, with 10 pressure stages, each consisting of one velocity stage. Two bleeder connections, one from 7th and one from 8th stages, by which steam is extracted for feedwater heating.

Mean diameter of first 7 wheels, 6 ft., 6 3/4 in.
Mean diameter of last 3 wheels, 9 ft., 2 in.
Length of blades of last stage, 22 1/2 in.
Lubricating-oil pressure, 10.7 lb. per sq. in.
Oil pressure for valve operation, 55 to 70 lb. per sq. in.
Capacity of lubricating oil pump, 400 gal. per min.

Turbine regulation, throttling.

GUARANTEED TURBINE STEAM CONSUMPTION WITHOUT BLEEDING

Load, Kilowatts	Consumption, Lb. per Kw-Hr.
40,000	9.32
30,000	9.46
20,000	9.9
10,000	11.0

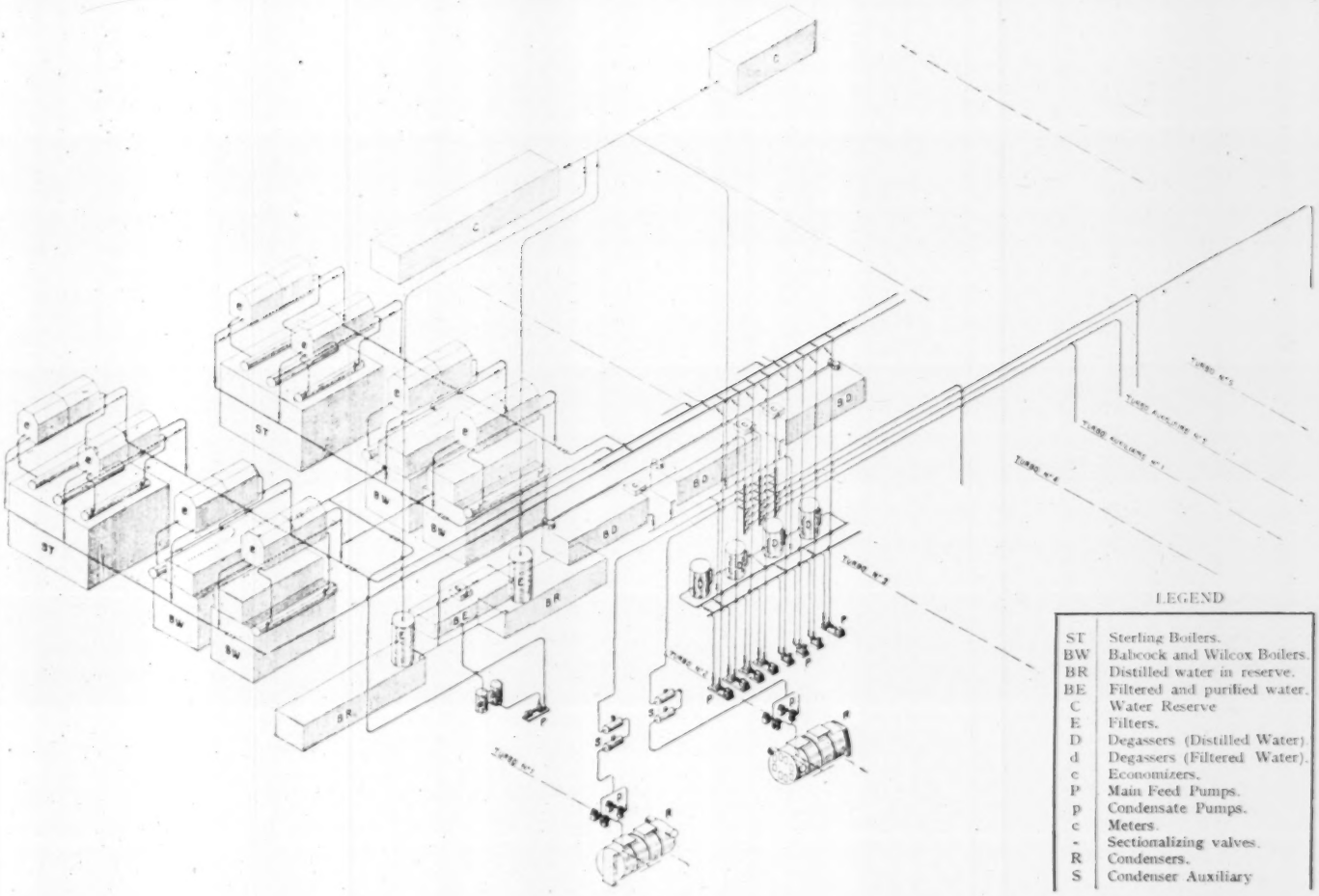
CONDENSING EQUIPMENT

The main condensers are identical for all units, all single-pass.
Condensing surface, 37,650 sq. ft. 0.94 sq. ft. per kw.

Diameter of tubes:	Inside, in.	0.787
	Outside, in.	0.866
Circulating pumps:	2 per unit, one being a spare;	
	Capacity 30,000 gal. per min.	
	Type, single-stage centrifugal	
	Drive: Electric for regular service; duplex (electric and steam turbine with reduction gears) for the spare.	
Condensate pumps:	2 per condenser, one being a spare;	
	Capacity, 720 gal. per min.	
	Type, 2-stage centrifugal;	
	Drive, electric for both sets.	
Air extraction:	4 ejectors per condenser, 2 being spares.	
	Rated output at 225 lb. steam pressure.	

SUMMARY OF STATION DESIGN CONSTANTS

Steam Conditions at Throttle:	
1. Pressure, pounds gage	313
2. Total temperature deg. fahr.	705
3. Superheat, deg. fahr.	280
Boiler Room:	
4. Sq. ft. of boiler heating surface per kilowatt station capacity	1.28



LEGEND

ST	Sterling Boilers.
BW	Babcock and Wilcox Boilers.
BR	Distilled water in reserve.
BE	Filtered and purified water.
C	Water Reserve
E	Filters.
D	Degassers (Distilled Water).
d	Degassers (Filtered Water).
c	Economizers.
P	Main Feed Pumps.
p	Condensate Pumps.
c	Meters.
-	Sectionalizing valves.
R	Condensers.
S	Condenser Auxiliary

FIG. 3

		Stirling	Babcock & Wilcox
5.	Sq. ft. of heating surface per sq. ft. of grate	34.3	36.3
6.	Cu. ft. of combustion space per sq. ft. of grate	2.08	7.8
7.	Sq. ft. of superheater surface per sq. ft. of heating surface	0.476	0.573
8.	Sq. ft. of economizer surface per sq. ft. of heating surface	0.572	0.602
9.	Sq. ft. of air-preheating surface per sq. ft. of heating surface	0.857	0.844
10.	Cu. ft. of water per cu. ft. steam in boilers	3.24	2.21
11.	Cu. ft. of water in boilers per sq. ft. of heating surface	0.127	0.090
12.	Forced-draft fan-motor output per sq. ft. grate, horsepower; normal rate of firing	0.261	0.294
	Do., 2-hour overload	0.364	0.406
13.	Induced-draft fan-motor output per sq. ft. grate, horsepower; normal rate of firing	0.033	0.035
	Do., 2-hour overload	0.133	0.140
	Turbine Room:		
14.	Sq. ft. of condensing surface per kilowatt capacity		941
15.	Ratio of circulating-pump capacity to condensate-pump capacity		42

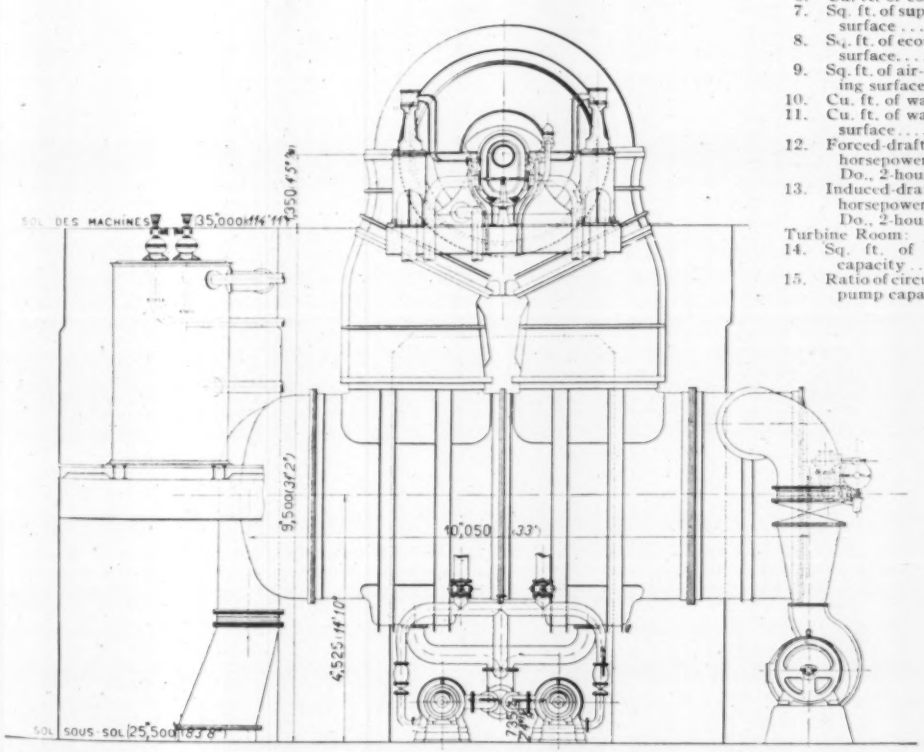


FIG. 4

FIG. 3 SCHEME OF CONDENSATE CIRCUIT OF THE GENNEVILLIERS STATION, PARIS

FIG. 4 40,000-KW. TURBO-GENERATOR; VIEW OF TURBINE END

(*Sol des Machines* = machine floor; *Sol Sous Sol* = basement floor.)

Short Abstracts of the Month

AERONAUTICS

ZEPPELIN-DORNIER AIRPLANE WITH INCLINED AXIS. Abstract from a British patent granted to the German Zeppelin Works and Dornier, describing an airplane so designed that it can take off and land in a small space. The axis of the machine forms an angle α of substantially 45 deg. with the horizontal. The axis C of the propeller forms the angle β with the axis A. It has an even greater inclination with regard to the horizontal than the axis of the monoplane. The tail has the usual runner D and, further, a hook-shaped braking spur E, by means of which the tail end of the machine can be retained on the ground at the start or at the landing. The braking spur is adapted to be pulled in from the pilot's seat by means of a pull rope, which is not illustrated. The invention can be applied to any type of airplane, but it is preferably designed to be used with monoplanes. (British patent no. 16,948. *Patent Office Journal*, Aug. 8, 1922. Compare *The Engineer*, vol. 134, no. 3483, Sept. 29, 1922, pp. 341, 1 fig., *d*)

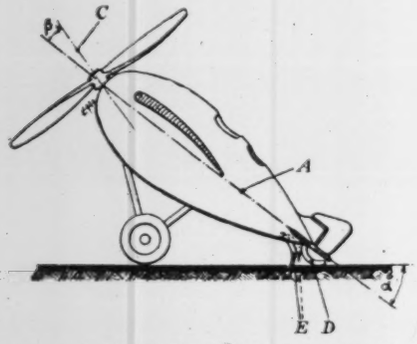


FIG. 1 ZEPPELIN-DORNIER AIRPLANE WITH INCLINED AXIS

AIRPLANE CRASHES IN THE U. S. ARMY AIR SERVICE DURING 1918 AND 1919. A total of 1250 reports of crashes were received from the various flying fields covering a period from the beginning of the war up to January 1, 1920, and the present investigation analyzes these reports in various ways. From these reports it would appear that bad landing was responsible for a little more than 45 per cent of the total accidents reported.

On the other hand, as regards the extent of injuries to pilots, a little more than one crash out of ten proved fatal, while in 807 out of the 1250 crashes the pilot was uninjured. To bad judgment are ascribed 47.52 per cent of the total crashes and to engine trouble, 21 per cent.

It would not appear that the age of the flier, hours of dual instruction received or experience in sole flying has any clear bearing on the number of crashes. As regards weather conditions, the figures themselves are not illuminating as 1092 out of a total of 1250 crashes occurred in fair weather, which is, however, probably due to the fact that most of the flying was also done in fair weather.

Taking up the question of age and its possible bearing on the cool judgment and resourcefulness so necessary in the case of a flier, it is interesting to note that the percentage of crashes attributed to bad judgment on the part of the pilot shows a steady decline as the tabulation proceeds from the young pilot of 18 or 20 to the more mature flier of 30 to 35 years of age. In reverse ratio are the percentages of crashes listed as unavoidable, which show that while only 12.08 per cent of all crashes occur among pilots from 18 to 20 years of age, more than twice as many (26.81 per cent) happen to those from 27 to 30 years of age.

In basing a conclusion on a table in the original article that age might have a tendency to promote prudence and carefulness in a pilot, and assuming that the ranking of pilots to a large extent followed their experience and natural ability as fliers, one would expect to find the percentage of crashes due to bad judgment on the part of the pilot steadily decreasing on passing from the lower ranking officers to the higher, and the percentage of unavoidable crashes steadily increasing. This is fully borne out by the statistical data available. (*Air Service Information Circular*, vol. 4, no. 340, May 1, 1922, pp. 1 to 22, *gA*)

AIR MACHINERY

Air Conditioning in Deep Mines—Reduction of Accidents

THE AIR-COOLING PLANT AT THE MORRO VELHO MINE OF THE ST. JOHN DEL REY MINING COMPANY, LTD., BRAZIL, Eric Davies. The plant is similar in principle to an ordinary cold-storage plant with the brine-circulation system. Since, however, the temperatures do not fall below 32 deg. fahr., ordinary water is used instead of brine and the place of the cold-storage chamber is taken by two large air coolers. Since the wet-bulb temperature of the air entering the plant is liable to vary between 75 and 32 deg. fahr. according to the season and time of day and it was desired to supply the mine with air at a fairly steady temperature, the plant is divided into six stages.

Two air coolers are always acting in parallel so that each handles approximately half the total quantity of the air. The air coolers are of the Heenan type (see MECHANICAL ENGINEERING, Feb., 1918, p. 190) and consist of a number of cylinders 10 ft. 10 in. in diameter which are built up of galvanized-steel plates 8 in. wide, arranged in a long spiral. These cylinders weigh three tons each.

Each air cooler has nine of these cylinders altogether, all arranged on one common shaft which is revolved at the rate of about 3 r.p.m. The lower parts of the revolving cylinders are immersed in six segmental tanks of water (one per stage), the mean temperature of which is maintained considerably below that of the air in that stage, and hence the air passing over the freshly wetted surface of the upper portion of the revolving cylinders has its temperature reduced.

The water tanks for each stage are piped up to the evaporator for that stage. The evaporators consist of large cast-iron tanks kept full of water to be cooled, and in them are immersed the coils of piping containing the ammonia undergoing evaporation. As regards the main ammonia compressors, there is one for each stage—a single-cylinder double-acting machine, 11⅝ in. bore by 21 in. stroke, belt-driven at 81 r.p.m.

The original article gives extensive data as to the results obtained which appear to be very satisfactory, both in the way of stabilization of temperature and of keeping it at a desirable level.

General improvement in underground conditions due to the cooling plant has also been reflected in the fall of the accident rate. In the sixteen months (August, 1919 to November, 1920, inclusive) previous to the starting up of the plant there occurred twenty deaths through underground accidents and four cases of disablement, the total liability for compensation involved in connection with these accidents being 80,675 milreis. In the following sixteen months (December, 1920 to March, 1922, inclusive) there were six fatal accidents underground and four cases of disablement, the amount of compensation involved being 35.820 milreis. These figures speak for themselves; they show that, owing to the more bracing condition of the underground atmosphere, the men are more alert and can perceive and avoid danger with greater celerity. There can be no doubt that the old trying and enervating conditions induced a sort of mental sluggishness, and where this state exists in the case of men who, as not infrequently occurs with the native labor at Morro Velho, are none too intelligent in the first place, disaster is all too often the result. There can also be no doubt that the frequent recurrence of fatal accidents during 1919 and 1920 was not only giving the mine a bad name among the natives (thus rendering it increasingly difficult to attract labor), but was also causing experienced and valuable miners to leave the company's service. This tendency has now been stopped to a great extent.

Another indication of the improved conditions is to be seen in the output returns. In the company's financial year ending February 28, 1921, the tonnage raised from the mine was 151,200, whereas the corresponding figure for the year ending February 28, 1922, was 169,234 tons, an increase of 17,935 tons, or nearly 12 per cent. Taking the value of the gold contained in each ton of ore as £ 3, which is approximately correct, it will be seen that the increased output in a single year's working has gone a long way toward paying for the company's total outlay in connection with the plant. (*Transactions of the Institution of Mining Engineers*, vol. 63, pt. 5, Aug., 1922, pp. 326–336, and discussion pp. 336–341, 2 plates, *dA*)

BUREAU OF STANDARDS (See Metallurgy)

ENGINEERING MATERIALS (See also Metallurgy; Testing and Measurements)

LAWS OF FAILURE OF SOLID BODIES DUE TO STRESS, Chido Sunatani. The author's theory is that the failure of a solid body subjected to stress is due to the occurrence of separated surfaces in its grains or throughout the body. He assumes the possibility of occurrence of three kinds of separation: namely, sliding separation, tensile separation, and a combination of the two. As regards sliding failure, the author propounds the following hypothesis: The shearing resistance of materials on the plane within a solid body decreases when the normal component of the stress acting on the plane increases algebraically, tensile strength being taken to be positive. The difference between this hypothesis and a similar one stated by Mohr lies in the fact that Mohr considers all failures to occur when shearing resistance is overcome, while the author of this paper considers that there are two kinds of resistance—shearing and tensile—and that failures due to either kind can occur in any material.

After a mathematical treatment of his hypothesis the author describes some tests made on sliding failure, by means of which he claims to have proved that his hypothesis is correct and that Mohr's theory cannot be a general law of failure of a solid body. He then proceeds to a consideration of tensile failure and the general conclusions of the paper are as follows:

1 There are two ways in which materials start to fail: by sliding and tensile separations; and two simple laws bearing thereon, which are now for the first time proposed by the author: namely, (*a*) True shearing strength increases or decreases proportionally with the normal component of the stress, as it is tensile or compressive, and may be expressed by the equation—

$$R_s = R_{so} - kN$$

where

R_s = shearing strength per unit area of a plane on which there exists a certain amount of normal component of stress, N

R_{so} = shearing strength of the plane where there is no normal component of stress, and which may be called the "true shearing strength" along the plane

k = a coefficient

and (*b*) True tensile strength decreases proportionally with the tangential component of stress, and may be expressed by the equation—

$$R_t = R_{to} - kS$$

where

R_t = tensile strength per unit area of a plane on which there exists a certain amount of the tangential component of stress, S

R_{to} = tensile strength of the plane when there is no amount of tangential component of stress, and which may be called the "true tensile strength" of the materials on the plane

k = a coefficient in a similar sense as in the case of sliding failure, and also assumed to be a constant for a given material

In both cases the proportional constant k is about 0.364 or ϕ about 20 deg.

2 In an isotropic body sliding or tensile failure occurs according as—

$$\frac{1}{2\cos\phi}\left\{T_1 - T_3 + (T_1 + T_3)\sin\phi\right\}$$

or

$$\frac{1}{2\cos\phi}\left\{T_1 - T_3 + (T_1 + T_3)\cos\phi\right\}$$

is greater than R_{so} or R_{to}, respectively, and the normal of the plane of failure lies in the plane perpendicular to the middle principal stress T_2, and makes an angle of $(\pi/4 - \phi/2)$ or $\phi/2$ with the greatest principal stress, according as it is a sliding failure or a tensile one. Consequently, we may anticipate the elastic or the breaking stress of a solid body under a certain state of stress if we know the corresponding value of R_{so} or R_{to} for its material, which is determined in any other state of stress of the material, and in some cases even if the value of R_{so} or R_{to} is not known.

3 New design formulas are derived as follows:

$$\frac{1}{2\cos\phi}\left\{T_1 - T_3 + (T_1 + T_3)\sin\phi\right\} > R_{so}$$

and

$$\frac{1}{2\cos\phi}\left\{T_1 - T_3 + (T_1 + T_3)\cos\phi\right\} > R_{to}$$

where T_1 and T_3 are the greatest and the least principal stresses at any point of the element in its working conditions.

From these formulas the values R_{so} and R_{to} of a brittle material can be obtained from a simple compression and a simple tension test, respectively, and that of R_{so} of ductile material from a simple tension test, but it seems difficult to find the value of R_{to} of ductile material and it is not necessary in practice. (*Journal of the Society of Mechanical Engineers*, Tokyo, Japan, vol. 25, no. 74, June, 1922, pp. 1–39 and 20 pp. of illustrations and plates, *teA*)

INVESTIGATION OF FORGED AND CAST BRASS. Tests were made with a view to determining the suitability of forged brass in gasoline pipe-line and tank fittings and to compare the soundness of forged and cast brass fittings. The tests were made on brass forgings submitted by a manufacturer and involved the chemical analysis, metallographic investigation, physical testing, and strain test. The results are as follows:

The chemical analysis shows that the metal used in the forgings is of the muntz metal type and is within the range of composition recommended for hot forgings or stamping by Guillet. Although the manufacturer claims that the forging of brass is a new process, brass has been successfully hot-forged or stamped in England for several years. It is know that there is danger of producing internal strains which result in season or spontaneous cracks. This condition is usually caused by forging at too low a temperature and can be readily detected in either the microstructure or by the mercurous nitrate test. Unless the cold work has been too severe, it may be remedied by annealing at a temperature ranging from 600 to 800 deg. fahr. The twinning of the alpha constituent in the annealed specimen indicates that this material has not been annealed subsequent to the forging operation. Another source of trouble encountered by the use of forged brass is the unequal hardness of different lots of metal, which seriously slows up the speed of machining when the parts are being turned out on a production basis. The variation in hardness is usually contributed to the chemical composition and so can be controlled. The hardness tests and the chemical composition of the forged fittings under test indicate that fittings made of this material could be readily machined.

It may be observed that the fittings cast in the Metals Branch Foundry are of tin bronze and not brass. The reason for this is that although the copper-tin alloy is more expensive, it gives a sounder casting and is more desirable for parts that are to hold water or gasoline. For that reason the gun metal rather than the red brass cast in the Metals Branch Foundry was taken as a basis with which to compare the forged brass. The properties of forged and cast brass are not really comparable, as the effect of either hot or cold work on a metal is well known, and it is to be expected that the forged material would be far superior to the cast. The particular forgings under test were forged from extruded bars so that the product is a result of two processes of hot-working along with the necessary annealing, all of which tends to produce a material more homogeneous and sound than that which is used in the final product as cast. (*Air Service Information Circular*, vol. 4, no. 335, Apr. 1, 1922, Material Section Report no. 158, 2 pp. of text and 2 pp. of photomicrographs, *e*)

THE EFFECT OF SUPERHEATED STEAM ON NON-FERROUS METALS USED IN LOCOMOTIVES, Sir Henry Fowler. The author reports on experiences with regard to the chief parts that are subjected to superheated steam in the case of superheated locomotives on the Midland Railway.

In piston tail-rod bushes several compounds were tried. For example, M. R. A. 1 gun metal and cast iron, of which the former was found to break in service and the latter to score the rods. Recourse was then made to a phosphor bronze containing 88 per cent copper, 11 per cent tin, and 1 per cent phosphorus, which gave entire satisfaction.

For piston-rod packing white-metal packing rings are used of

the following composition: lead, 70 per cent; antimony, 30 per cent. During solidification this metal is pressed into the mold by means of a flat piece of wood, as this has been found to give metal of greater soundness. Although this metal has been used for about 12 years and has given excellent satisfaction, apparently the temperatures met with today, say, 340 to 370 deg. cent. (644 to 698 deg. fahr.) are approaching its critical point and an increase above this figure has been found to cause trouble. This was the experience during the coal strike of last year when a number of engines were fired with oil in place of coal, which was found to give a higher degree of superheat, with the temperature rising to 425 deg. cent. (797 deg. fahr.). The trouble experienced was due to the packing rings' fusing.

As regards the by-pass valves, which are arranged in close communication between the ends of the cylinder, when steaming they are subjected not only to the temperature of the steam in the cylinders but also to considerable shock. Cast iron, gun metal, and phosphor bronze were tried and found wanting. A complex nickel brass with 3.33 per cent nickel and 38.05 per cent zinc was tried successfully, but on account of cost was replaced by malleable iron or steel castings. From all of these experiences it would appear that in the case of locomotive parts subjected to superheated steam, a metal which may prove satisfactory when not subjected to friction may be wholly unsuitable when it has a moving part working over it. (Paper presented at the *Institute of Metals*, Sept., 1922, abstracted from advance copy, 4 pp., *ep*)

Stainless Steels—Scaling, Dr. W. H. Hatfield. A general discussion, with data of tests of the properties of stainless steels.

As regards resistance to scaling, the author states that in comparison with ordinary carbon steels, stainless steel resists scaling to a marked degree with increasing temperature. Tests performed up to 1000 deg. cent. (1832 deg. fahr.) on mild steel, alloy steels, tungsten steels, and stainless steel showed that the stainless steel scaled less than any of the others.

The temper colors produced at much lower temperatures form an analogous phenomenon to scaling, and it is well known that when hardened tool steel is tempered, the originally bright surface goes through a series of colors. During this process of color change with increasing temperature the skin of the steel becomes seriously affected when visible red heat is attained. Stainless steel responds in a very different manner, and up to temperatures of 800 deg. cent. (1472 deg. fahr.) the effect on the surface is confined to the color effect only. The same temper colors obtained during tempering, in the case of stainless steel, correspond to much higher temperatures than in the case of carbon steel. (*Transactions of the Institution of Mining Engineers*, vol. 63, pt. 3, May, 1922, pp. 177–191 and discussion pp. 192–195, *g*)

Metallic Tantalum. The Fansteel Products Co., North Chicago, Ill., it is said, has developed a process for the production of metallic tantalum. The metal will necessarily be very high in price because it has to be made in a vacuum.

Its resistance to wet corrosion is its most interesting characteristic. It is unattacked by any acid or alkali solution (except hydrofluoric acid) even at boiling temperature.

Its high melting point—about 2850 deg. cent.—is of no commercial advantage as it oxidizes in air easily long before it reaches that point.

[It might be mentioned in this connection that tantalum was made in Germany for a number of years by a process developed by Dr. Von Bolton. Editor.]

The work for the Fansteel Company has been done by Dr. Clarence W. Balke. Further research work is being conducted by the same company on columbium, with a view to determining what commercial advantages this material may have. (*Chemical and Metallurgical Engineering*, vol. 27, no. 14, Oct. 4, 1922, pp. 704, *d*)

The Marine Borer. Data of work of the San Francisco Bay Marine Piling Committee, affecting particularly views concerning immunity from the teredo. Prof. C. A. Kofoid of the University of California was in charge of the biological work.

In the course of the work of the committee it was determined that the teredo can continue to feed and function in water of a minimum salinity of five parts per thousand; all previous investigations placed the minimum at nine parts per thousand. It was also discovered that the teredo can endure exposure to entirely fresh water for a period of at least twenty days and can live in conditions of putrefaction involving the entire exclusion of dissolved oxygen from the water for at least ten days. The marked winter dying off of teredo in the Carquinez Strait region has been proved to be due not to reduction of salinity, but to be caused by a fungus and bacteria infection.

Based on the biological work, the Marine Piling Committee has worked out tentative specifications for creosoted oil and the treatment of timber with this material for protection from marine borers; also, at the instance of the San Francisco Committee, the National Research Council, Washington, D. C., has appointed a special committee on marine-borer investigation that will explore and correlate the work on this subject through the United States. (*Pacific Marine Review*, vol. 19, no. 8, Aug., 1922, pp. 452–453, *edA*)

FUELS AND FIRING

Conveying Coal Dust Through Gas Mains

Conveying Finely Pulverized Fuels Through Gas Mains, Dr. Engr. Wittfeld. Dust particles of very small grain size fall only very slowly in gases, even when these latter are strongly rarefied. A good indication of the ability of dust to stay in suspension is given by the so-called twilight phenomena occurring after violent eruptions of submarine volcanoes. These phenomena are due to the fact that extremely fine dust is thrown to great heights and forms there clouds which give well-known peculiar lighting effects. That such dust is formed in eruptions of submarine volcanoes is due to the action of steam.

This behavior of fine dust may be utilized in the conveying of finely pulverized fuels to considerable distances by means of gas mains. Conditions are particularly favorable for applying this process to the handling of semi-coke. The process of manufacturing of semi-coke is now only in its infancy, but when it develops the problem will arise of how to deliver it to consumers. This fuel is of a very brittle character and therefore not well suited for shipment in open cars. However, because of its brittleness it is very easy to pulverize, and it can then be used for firing boilers equipped with proper devices. Furthermore, semi-coke plants yield considerable quantities of products of incomplete combustion in the form of gas, and this gas may be used for lighting and house and industrial heating. It would therefore appear logical to pulverize the semi-coke at the plant where it is made, and in the form of fine dust deliver it to the place of consumption together with and carried by the by-product gases.

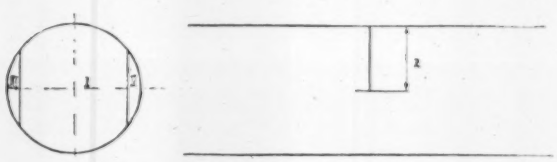


Fig. 2 Fig. 3

Fig. 2 Diagram Showing Position of Deflectors in Dust-Gas Mains with Respect to the Cross-Section of Main

Fig. 3 Velocity Diagram Used in Connection with Equation [1]

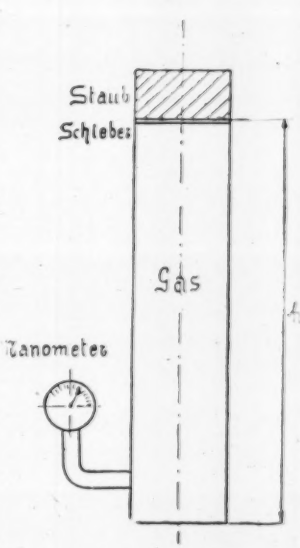


Fig. 4 Device for Determining Velocity of Fall of a Given Dust in a Given Gas
(*Staub* = dust; *Schieber* = valve.)

No special difficulties are involved in separating the dust from the gas. All that it is necessary to do is to pass the gas through a filter which will retain the dust. In fact, where lignite or peat are used as the raw material of gas and semi-coke manufacture, it may be necessary to permit the gas to retain a certain amount of the coke dust in order to increase its heating capacity.

The gas mains should be equipped with side outlets to permit the supply of local industrial plants with semi-coke dust and gas. It will be advisable to lay them so that they will be horizontal and free of bends along their entire length. In many instances this can be done, but where it is impossible owing to ground conditions, the suspended dust an undulatory path of travel. Such deflectors need to be installed only over the part of the cross-section indicated by *I*. In the remainder of the cross-section (*II*, *II*) the flow of the dust is quite irregular, but this increases the power consumption of the pumps only to a slight extent. The spacing of the deflectors may be determined in the following manner.

Referring to Fig. 3, let c be the limiting velocity of flow of the dust and w the velocity of flow of the gas, and let it be assumed that there is a simple straight-line relation between the resistance to fall (suspension resistance) of the dust and a certain velocity of fall v; then—

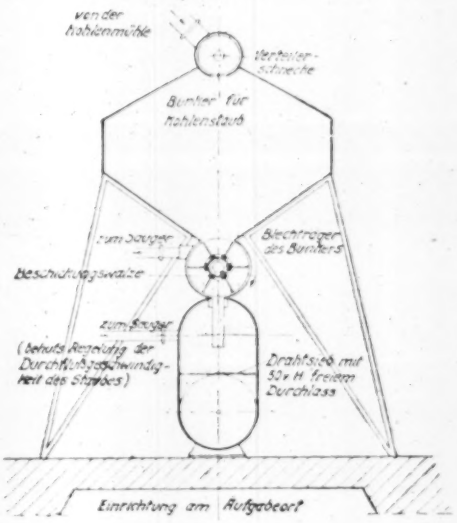


FIG. 5

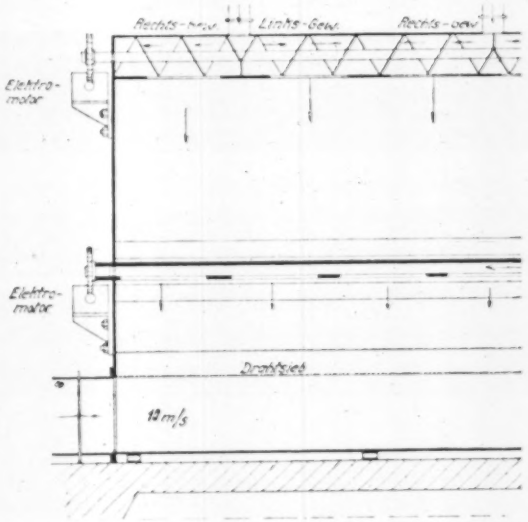


FIG. 6

FIGS. 5 AND 6 DIAGRAMS OF PLANT WHERE THE MIXING OF THE GAS AND COAL DUST IS EFFECTED

(Fig. 5: *von der Kohlenmühle* = from coal crusher; *Verteilerschnecke* = distributor worm; *Bunker für Kohlenstaub* = coal dust bin; *zum Sauger* = to suction fan; *Beschickungswalze* = feed roll; *Blechträger des Bunkers* = bin supports; *Drahtsieb mit 50 v. H. freiem Durchlass* = wire screen 50 per cent mesh; *behufs Regelung der Durchflussgeschwindigkeit des Staubes* = for properly regulating the velocity of flow of the dust; *Einrichtung am Aufgabeort* = equipment at mixing station. Fig. 6: *Rechts-Gew.* = right-hand thread (of worm screw); *Links-Gew.* = left-hand thread; *Drahtsieb* = wire screen; *10 m/s* = 10 meters per sec.)

charging stations will have to be installed; this, however, can be done only to a limited extent on account of the increased first cost and cost of operation. Where the mains are on one level and run in a straight line, there is no reason why the cost of delivering the mixture of gas and dust should be much higher than the cost of handling gas alone. Spaced from each other at certain intervals s, deflectors (Fig. 2) may have to be installed in the pipe in order to force the gas to flow in an upward direction and thereby give

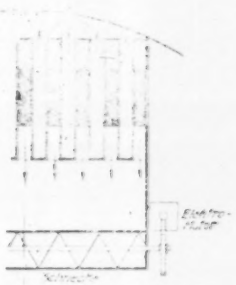


FIG. 7

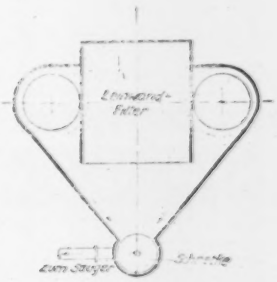


FIG. 8

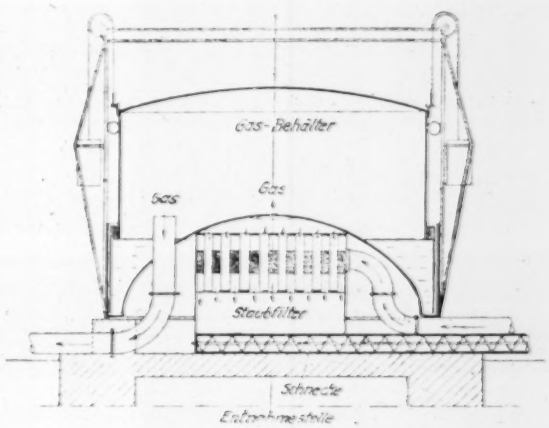


FIG. 9

FIGS. 7, 8 AND 9 VIEWS OF DELIVERY PLANT SHOWING SEPARATION OF COAL DUST FROM GAS

(Fig. 7: *Drahtsiebe* = wire screen; *Schnecke* = conveyor worm. Fig. 8: *Leinwand Filter* = cloth filter; *zum Sauger* = to suction fan; *Schnecke* = conveyor worm. Fig. 9: *Gas Behälter* = gas holder; *Staubfilter* = dust filter; *Schnecke* = conveyor worm; *Entnahmelselle* = coal-dust delivery plant.)

FIG. 10 BAFFLE IN GAS MAIN FOR PRODUCING AN ASCENDING FLOW OF THE COAL-DUST-GAS MIXTURE

(German text under illustration substantially translated in above caption.)

$$\frac{dv}{dt} = \left(1 - \frac{v}{c}\right) g, \; v = c\left(1 - e^{-\frac{g't}{c}}\right), \; z = ct - \frac{c^2}{g}\left(1 - e^{-\frac{g't}{c}}\right) \quad [1]$$

As it passes into the mains the dust enters the gas stream with a vertical velocity v_0. Hence, for the distance s_0 between that point and the nearest deflector,

$$v = c\left(1 - e^{-\frac{g't}{c}}\right) + v_0, \text{ and } z = (c + v_0)\, t - \frac{c^2}{g}\left(1 - e^{-\frac{g't}{c}}\right)$$

The length of pipe traversed by the dust flowing with the gas during the time t is $x = wt$. If D is the diameter of the pipe, the following equations may be used for computing s_0 and s:

$$D = \frac{c + v_0}{w} s_0 - \frac{c^2}{g}\left(1 - e^{-\frac{g s_0}{wc}}\right)$$

and—

$$D = \frac{c}{w}\, s - \frac{c^2}{g}\left(1 - e^{-\frac{gs}{wc}}\right)$$

In order to determine the limiting velocity c, semi-coke dust may be allowed to fall in a glass tube filled with gas at a known pressure. If T is the time taken by the dust to fall through the distance h (Fig. 4), then the velocity c may be obtained from the equation—

$$h - cT + \frac{c^2}{g}\left(1 - e^{\frac{-gT}{c}}\right) = 0$$

Such combined gas and pulverized-fuel conduit systems may prove to be economically preferable in certain cases to the long-distance transmission of power by electrical means. Figs. 8 to 10 show what is considered to be a workable arrangement for such a transmission, for the dust falling at low velocity is delivered through a wire screen at right angles to the rapidly flowing stream of gas (Figs. 5 and 6) and separated therefrom at its destination by screens and impact action (Figs. 7, 8 and 9). Fig. 10 indicates diagrammatically the motion of the dust in the gas main.

Only by means of tests can the facts regarding the behavior of dust in gas mains of this character and the power requirements be determined, and it would be advisable in view of the importance of the subject to institute such tests. (*Fördertechnik und Frachtverkehr*, vol. 15, no. 9, Sept. 15, 1922, pp. 247–248, 9 figs., *dA*)

THE COMPARATIVE MERITS OF BENZOL AND GASOLINE AS ENGINE FUELS, W. O. Hinckley. The author briefly describes the process of manufacturing benzol and gives a specification for motor benzol, which is also compared with the specifications of gasoline.

It is found that the end point of the gasoline sample was 417 deg. fahr. as compared with 275 deg. for the motor benzol. There was a residue of 0.2 per cent with gasoline on distillation and none with motor benzol. The so-called end point is important, as a high end point indicates the presence of poorly volatilized constituents, such as kerosene, which, if present in too great an amount, would reduce the efficiency of the motor fuel. Various methods may be used in demonstrating this. One, for example, is to compare the time of evaporation or volatilization of a fuel having a high end point with one of a low end point (time for benzol, 26 min., and for typical motor gasoline, 145 min.).

The heat value of the motor benzol is about 18,700 B.t.u. per lb. as compared with 17,460 B.t.u. per lb. for gasoline. The difference is still more striking when considered on the basis of volume, as benzol has a greater specific weight and its value is 137,000 B.t.u. per gal. as compared with 113,500 B.t.u. per gal. for gasoline.

In tests made on a four-cylinder engine an increase of horsepower with motor benzol as compared with gasoline is claimed, as well as better performance. The tests, however, were not extensive enough to establish any reliable conclusion. (*Journal of the Society of Automotive Engineers*, vol. 11, no. 4, Oct., 1922, pp. 359–360, 1 fig., and discussion pp. 360–362, *ce*)

HANDLING PULVERIZED COAL BY NOVEL METHOD. In the plans for equipment to be used by the new Cahokia Station of the Union Electric Light and Power Co., St. Louis, a novel method of weighing the fuel and conveying it from the pulverizers to the boilers is proposed.

A series of five blowing tanks will be placed below the floor level of the pulverizing room which will serve an equal number of pulverizing units. These blowing tanks will rest on platform scales, the dial of which will indicate to the operator in the pulverizing room the amount of fuel in the tank.

The fuel will feed into these tanks by gravity as desired from the fuel bins in the pulverizing room. Each charge will be weighed automatically and then elevated by compressed air to a height of about 75 ft. through 4-in. pipes. By means of a simple system of switching valves and parallel distributing mains cross-connected, any blowing unit can discharge into any of the eight enclosed storage hoppers in the boiler house.

The fuel requirements of the first group of units are estimated at 1000 tons in 16 hr. (*Iron Trade Review*, vol. 71, no. 15, Oct. 12, 1922, pp. 988, *d*)

GAS PRODUCERS

Suction-Gas Trucks and Tractors

FRENCH SUCTION-GAS TRUCKS AND TRACTORS. Opportunities for the successful use of suction gas on commercial automotive equipment are greater in France than in most other countries on account of the high price of gasoline and abundance of charcoal.

The present fitting of suction-gas plants to trucks and tractors marks a period of transition, provision being made to use gasoline when the engine is required to develop temporarily more power, the suction-gas plant being usually installed as additional equipment.

The present article describes the "Lion" plant, the unit of the French Company of Agricultural and Industrial Material of Vierzon, and the Cazes suction-gas producer. All of them are intended to operate primarily on charcoal. The Vierzon Company's gas producer may employ also small chopped wood as fuel, or a mixture of charcoal and wood. As an example of the design the Cazes unit (Fig. 11) may be described. The producer A, lined with

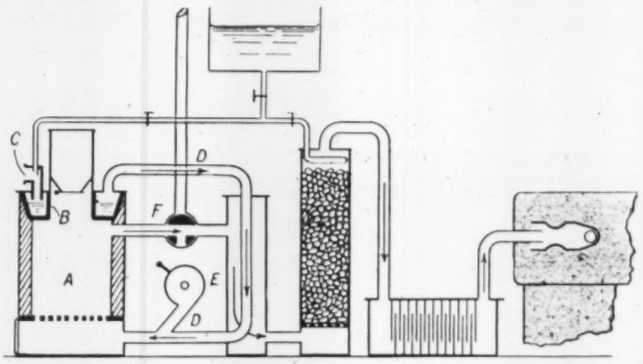


FIG. 11 THE CAZES SUCTION-GAS PRODUCER AS APPLIED TO TRACTORS

refractory material, has an annular steam generator B with air admission at C. The air on being drawn over the surface of the hot water takes up a certain quantity of steam, after which it passes through the pipe D to the bottom of the producer; this pipe also passes through the economizer E. The gas from the upper part of the producer continues its course by the pipe F into the economizer where it is cooled by contact with the walls, and also gives up part of its heat to the pipe D to raise the temperature of the steam-saturated air. Thence the gas enters the scrubber and finally into a condenser provided with a series of baffle plates which free the gas from any water and impurities. It is claimed that this system of recuperating the heat increases the calorific value of the gas and that consequently more power is developed in the engine. This would seem to be confirmed by the results of the Paris trials, when the 100-mm. by 150-mm. engine developed on the bench 20.4 hp., and the consumption of charcoal with a load of $3\frac{1}{2}$ tons was $54\frac{1}{2}$ kg. on the first day's run of $37\frac{1}{4}$ miles and on the second day 46 kg. It is true that the length of the engine stroke gave an advantage for the combustion of gas.

The Cazes producers have been used successfully on agricultural tractors, and in plowing tests a Tourand-Latil tractor equipped with this plant plowed $2\frac{1}{2}$ acres with a consumption of 45 kg. of charcoal of which the cost was 8.40 francs. In the latest type of suction-gas plant recently adapted to lorries the scrubber and condenser have been done away with and have been replaced by a double oil filter. In this way the weight has been reduced from 1120 lb. to 560 lb. The tendency of all makers of suction-gas plants for motor vehicles is to simplify them as much as possible by omitting the scrubber with its water supply, and the results already obtained with different systems tend to show that improvements will be carried out in the direction of compact and unobtrusive plants which will help to popularize the employment of suction gas for commercial vehicles. (*The Engineer*, vol. 134, no. 3483, Sept. 29, 1922, pp. 332–334, 9 figs., *dc*)

AUTOMATICALLY CONTROLLED WATER-GAS PRODUCER, G. Vigreux. The feature of the apparatus described is that the blow and gas-making periods are equal, which allows of the joint working of two

units for a continuous production of gas and of economy in the size of the container required.

The reversing movements of the valves are effected automatically by power, while the air and steam deliveries are regulated by means of indicators and manometers. The sensible heat and the combustion heat of the blow gases are both controlled.

It was found to be essential to the scheme to have certain quantities of heat stored in the generator in order not to have to increase the blow or vary the steam delivery for any one period or successive periods. This is achieved by the special construction of the generator shown in the original article. (From a paper read at the Annual Meeting of the Société Technique du Gaz, abstracted through *Gas Journal*, vol. 159, no. 3095, Sept. 6, 1922, pp. 531, 1 fig., *d*)

HYDRAULIC ENGINEERING

Experiments on a Pelton Wheel and Needle Nozzle

EXPERIMENTS ON A PELTON WHEEL AND NEEDLE NOZZLE, Prof. A. H. Gibson. Experiments were carried out on a Pelton wheel forming part of the equipment of the author's hydraulic laboratory at the University of Manchester. As originally installed by the makers, this gave only moderate efficiencies. After modifications the efficiency was improved by some 15 per cent. The machine is a single wheel carrying 20 buckets and is supplied through a 6-in. pipe line terminating in a needle nozzle 1.57 in. in diameter. The jet from this cuts the bucket circle at a radius of 11.30 in., the diameter of the wheel over the tips of the bucket in the center line of the jet being 24.25 in.

In preliminary tests it was found that contrary to usual practice in this plant maximum efficiency was attained with an opening corresponding to about half-load, and an inspection of the jet through a glass panel on the turbine casing afforded grounds for belief that the reduction in efficiency may be partly due to the jet itself, as a distinct spreading of the jet after leaving the nozzle was observed, particularly with the larger openings. This spreading was apparently due to the water reaching the nozzle with a considerable velocity of whirl.

With a view to reducing the velocity of whirl of the water the nozzle was unshipped and four radial vanes made of $^1/_{16}$-in. sheet brass, each 6 in. long and 1 in. deep, were fitted as shown in Fig. 12. The effect of this alteration was very marked. For all openings the jet became perfectly solid and sensibly parallel up to its point of impact with the buckets, and with smaller openings had a clear glassy appearance indicating steady as opposed to sinuous motion.

Careful measurements with a view to determining the coefficients of contraction were made, and from these it appears that the coefficient of contraction is within the errors of measurement the same for 60 ft. as for 96 ft. head. The efficiency at first increases with the opening, but as the opening is increased beyond about three and a half turns there is a very marked diminution in velocity and efficiency. This attains a minimum value for an opening of about five and a half turns, at which the efficiency is only about 90 per cent.

Tests were also made with a modified form of nozzle and data on these presented in the original article. Additional series of experiments were made in order to determine the loss in mechanical friction and in windage. It was found that the horsepower consumed by friction and windage is proportional to the 2.17 power of the speed. Assuming, as appears to be justified by recent experiments, that the moment of mechanical friction of a well-lubricated high-speed bearing is sensibly independent of the speed and load and that the windage resistance is proportional to the square of the speed, the frictional moment T may be expressed as $a + bs^2$, where a and b are constants ($a = 1.25$; $b = 0.0000194$) and s the speed in r.p.m.

An interesting discussion of losses in buckets and kinetic energy of discharge is presented. This part, however, is not suitable for abstracting.

One of the features particularly emphasized by the author is the possibility of the rotary motion being produced by a bend, or generally by an obstruction in the pipe line. The experiments showed that during motion round a bend the velocity is greatest and the pressure least near the inside of the bend. In fact, the flow is somewhat analogous to that obtaining in a free vortex. The equalization of these pressures and velocities at the entrance to the straight portion of the pipe is accompanied by eddy formation, which appears to be the chief source of loss of energy occurring in curvilinear as opposed to straight-line flow. One incidental effect of the variation of pressure at the beginning of the straight portion is to set up a system of circulatory currents from the region of higher to that of lower pressure. Any irregularity in the cross-section of the pipe, or any difference in the roughness of the two halves of its periphery must, however, tend to increase the relative resistance to the flow of one of the outflowing branches of this current. In every case investigated by the author such a motion has been found superposed on the general motion of translation of the water, and the fact that this increases the relative velocity of water and walls for a given mean velocity of flow, must account for some, at all events, of the resistance to flow around a bend.

The tests indicate that the efficiency of a well-designed wheel and

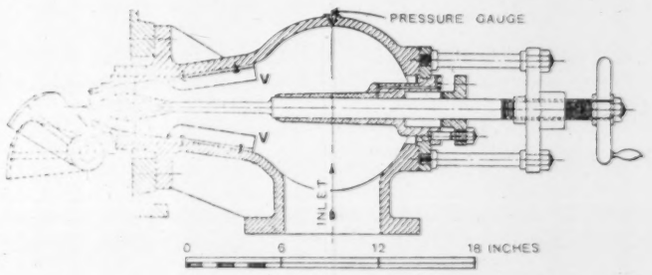


FIG. 12 NOZZLE AND REGULATING NEEDLE IN EXPERIMENTAL PELTON WHEEL

nozzle, even of small power, may be surprisingly high. In spite of the comparative smallness of the buckets, the actual efficiency of this plant attained a value of 79 per cent, and this with a jet efficiency of only 94 per cent. Experiments on other wheels with more perfectly designed nozzles show that the jet efficiency may readily be brought up to 97 per cent, which, with the present buckets, would give an overall efficiency of 82 per cent, while with larger buckets and the more efficient jet there would appear to be no reason why this overall efficiency should not attain a value in the neighborhood of 85 per cent. (*Proceedings of the Institution of Mechanical Engineers*, no. 3, 1922, pp. 643–661, 8 figs., *e*)

INTERNAL-COMBUSTION ENGINEERING (See also Fuels and Firing)

WILSON SLEEVE-VALVE SUPERCHARGER ENGINE. Description of a supercharger engine designed in England. As constructed the experimental engine has two vertical cylinders, but the principle is equally suitable for a multi-cylinder engine. The power unit consists of two vertical cylinders in each of which is a single sleeve-valve having suitable ports and a piston of ordinary construction. The two pistons work in unison, their cranks being set at 360 deg., i.e., a common crankpin is employed. The sleeves are operated by connecting rods off a small crankshaft running at half the main crankshaft speed and the sleeve cranks are set at 180 deg.

Crankcase compression is employed. On each upstroke of the two pistons a double charge is drawn into the crankcase through ports in each sleeve registering with the carburetor. On the pistons descending, they compress the charge in the crankcase, and another port in the sleeve of one cylinder then allows the compressed charge to be transferred to the combustion space of this cylinder. This completes the two-cycle operation which takes place in the crankcase.

In the cylinder there is a four-cycle operation in progress. As the pistons rise, one is on its compression stroke and the other on its exhaust stroke, since the sleeve-operating cranks are at 180 deg. As the piston, which is on its exhaust stroke, reaches the top dead center, the port in the sleeve through which the exhaust gases have passed is closed, and as the piston descends with all ports closed a partial vacuum is formed in the cylinder, until the piston uncovers the next series of ports, which at this moment are in communication with the carburetor. Accordingly, a charge is drawn into the cylinder, and as the piston descends the transfer port is

opened and the compressed charge in the crankcase is also forced through into the cylinder. The piston then ascends on the compression stroke in the ordinary way, all ports being closed, and the mixture is fired and the piston forced down on the working stroke when at a suitable moment the exhaust port is opened and the products of combustion are swept out as the piston rises on the exhaust stroke.

In the original article diagrams are given illustrating the cycle of operations of the engine. No data of any tests are given. (*The Autocar*, vol. 49, no. 1406, Sept. 29, 1922, pp. 596–597, 1 fig., *d*)

WHAT CAN WE EXPECT FROM THE COMPOUND GAS ENGINE? Prof. W. J. Wohlenberg, Assoc-Mem. Am.Soc.M.E. The author points out that no experimental data are available on engines operating with the intercooling process, although Ricardo and certain European engineers have worked on modifications of the process for the purpose of increasing the possible mean effective pressure in a given cylinder. It is therefore not possible to compare the relative performance of actual engines.

Analytically, the author comes to the conclusion that maximum efficiency is not obtained with complete expansion, and, further, that for Otto compression ratios below six the intercooling cycle has a decided thermal advantage, but for compression ratios over seven the Otto cycle is preferable.

For normal loading the intercooling engine possesses a decided advantage thermally. For quality governing this advantage disappears at light loads. In fact, the author shows that under certain conditions 53 per cent more work may be accomplished per cycle by the intercooling engine, while the ideal thermal efficiency of the cycle is 58 per cent. At the same time an analysis of the weights of the parts in an intercooled engine would indicate that it is improbable that the weight of the additional parts will serve to offset as large a gain in power as 53 per cent. Moreover, if proper precautions are taken the combustion process in the intercooling engine should be at least as good as in the Otto engine. On the other hand, however, the author comes to the conclusion that the intercooling process is at a thermal and power disadvantage when it is not the means of increasing the final compression pressure. (*Power*, vol. 56, no. 15, Oct. 10, 1922, pp. 560–562, 4 figs., *c*)

5000-R.P.M. Engine with Positive Valve Control

BIGNAN ENGINE WITH POSITIVE VALVE CONTROL. This design is primarily applicable to high-speed engines such as may be used in racing cars.

Each valve stem carries a guide working on two vertical shafts and carrying two conical rollers which take their motion from a cam the form of which in plan is a circular disk. The valve movement is then positively controlled and springs are entirely eliminated. The system is given the name "Desmodromique" by its designers.

The overhead valve gear is arranged in two groups, one over each pair of cylinders. The four valves in each group are spaced out in the form of a square, the diagonals of which intersect at the center of the circular cams. Thus, one cam operating the two inlet or two exhaust valves, as the case may be, brings one valve into action 90 deg. after the other, which corresponds, of course, to 180 deg. on the crankshaft since the driving shaft operating the valve gear runs at half the engine speed. The cams are so formed as to bring the valves gently to their seats, pressure within the cylinder holding them there, while the flat or non-acting portion of the cam passes between the rollers until they are opened again.

The cams are driven by bevel pinions from a centrally located horizontal overhead shaft, which, in turn, is driven by skew gears off a vertical shaft, the whole mechanism running in a bath of oil. This gear is said to have been already tested in practice, the engine thus equipped having attained a speed of 5000 r.p.m. (*The Autocar*, vol. 69, no. 1407, October 6, 1922, p. 626, 2 figs., *d*)

ADAMS STEPPED-PISTON SOLID-INJECTION ENGINE. Description of an engine of moderate power designed to operate on low-grade asphalt-base fuel oils of the types produced in the Californian and Mexican fields. It is a direct reversible two-cycle motor and is built by E. T. Adams & Sons, Los Angeles, Cal.

Notwithstanding the fact that it is of the two-stroke-cycle type, it employs a flat-top piston without any deflectors, this being made possible by the arrangement and timing of air ports. Another feature of the engine is the use of an excess of scavenging air with the view to producing better scavenging and more complete combustion of the fuel. This scavenge air is compressed in the chamber formed by the step or enlarged lower section of the piston and cylinder, and not by separately driven scavenging pumps or by crankcase compression. The design is such that scavenge air is compressed in each cylinder for use in that same cylinder. (*Motorship*, vol. 7, no. 10, pp. 750–751, 5 figs., *d*)

COMBINED POPPET- AND SLEEVE-VALVE ENGINE. Data of tests conducted at Armour Institute of Technology on a single-cylinder engine built by Victor R. Stenger.

The engine was made to test a valve layout (Fig. 13) which consists of a single poppet valve *A*, carried on a cage *B*, which also acts as a guide for the sleeve valve *C*. This cage is in reality the cylinder head and is held in place by the nut *D* threaded into the cylinder block. The poppet valve is operated in the conventional manner by the rocker arm *E*. The sleeve is operated in much the same manner by two parallel rocker arms *F*. The inlet and exhaust ports are shown by *G* and *H*, respectively.

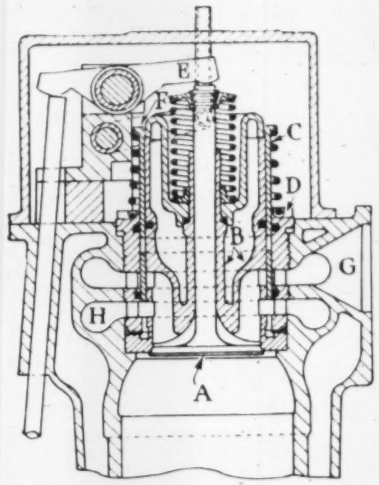


FIG. 13 SECTIONAL VIEW OF STENGER COMBINED POPPET- AND SLEEVE-VALVE ENGINE

It is claimed that this valve layout provides a greater ratio of valve area to cylinder volume, with consequent smaller throttling of the incoming and outgoing gases. The original article gives power, torque, and fuel-consumption curves of the engine tested which is a single-cylinder, 4-in. by $5^3/_4$-in. unit running on ordinary commercial gasoline. (*Automotive Industries*, vol. 47, no. 16, Oct. 19, 1922, pp. 765, 2 figs., *d*)

UTILIZATION OF EXHAUST GASES, S. Snuyff. It is the author's opinion that the most economical way to utilize the exhaust gases from slow-speed Diesel engines is to lead them through a steam boiler and generate steam to be used in a steam engine, either reciprocating or turbine type, with a condenser. He advocates the use of a reciprocating steam engine rather than a combined Diesel-steam as in the Still engine. He comes to the conclusion that by installing an effective steam boiler with superheater, feedwater heater, etc., utilizing the exhaust heat of the engines and generating steam, connecting this to a turbo-electric set which delivers power to a motor direct-coupled to the main engine, the power can be increased by about 120 hp. for every 1000 b.hp. of the main engine. The author discusses the question of the respective weights and gives data on the conditions of operation of the compound plant. An appended editorial note states that in the article there are many problematical and theoretical aspects on which other engineers may have alternative views. (*Motorship*, vol. 7, no. 10, Oct., 1922, pp. 770–771, *g*)

VAPORIZATION OF MOTOR FUELS, P. S. Tice. Among other things, it is pointed out that change in pressure in the engine intake are of great importance in their effect on vaporization, particularly the changes following manipulation of the throttle.

As regards vaporization in the cylinder, the author does not believe that the conditions there are such as to make it possible to rely upon turbulence to build up a usable vapor content in the charge. (*Journal of the Society of Automotive Engineers*, vol. 11, no. 4, Oct., 1922, pp. 307-314, 7 figs., and discussion pp. 314-319, *ge*)

MACHINE TOOLS

Large Surfacing and Boring Machine

LARGE SURFACING AND BORING MACHINE. Description of a machine, notable both for its size and details of construction, specially constructed by H. W. Kearns & Co., Ltd., Broadheath, near Manchester, England, for performing the machining operations on steam-turbine casings without resetting. This machine is shown in elevation and plan in Fig. 14.

Its weight is approximately 100 tons and it embodies such features as a traveling spindle of large diameter and an automatic facing motion. The spindle can be revolved either independently or simultaneously with the facing slide and the machine is capable of performing both boring and facing operations simultaneously. For boring work of medium diameter the facing slide does not revolve. Reverse motions are fitted both to the spindle and the facing slide, and the machine is fully automatic with reversible power feeds to the spindle, facing slide, vertical motion of the spindle slide, and the horizontal and transverse motions of the table. Rapid power traverse is fitted to all these movements, as well as to the longitudinal movement of the boring stay along the bed and to the vertical motion of the boring-bar support. In addition to these movements the turntable, which is detachable, can be caused to revolve in either direction by power. It can also be turned by the automatic feed, enabling continuous milling to be performed in a circular path. The facing slide is of the slotted type which allows of the tools being placed in the most convenient positions, while for wide faces two or more tools can be used simultaneously.

The spindle slide and the boring stay are balanced, the weights being carried inside the castings. The spindle slide and the boring stay can be moved together or independently, so that once the alignment has been obtained for the boring bar, it can be retained. Vernier scales are not fitted for this purpose, dial traverse indicators which give the reading of the height above any given indicators which give the reading of the height above any given date of line being used. These indicators are actuated by non-rotating screws, as already described in *The Engineer*. All the screws which operate the traverse are kept in tension and the end thrusts are taken by large bowl washers.

The capstan for the power and quick hand traverse for the spindle serves a double purpose. The handles used for moving the spindle require only a forward push to engage the automatic feed. The quick power motor circuit cannot be completed so long as the automatic feed lever is engaged. The traverse of the spindle of 48 in. at one setting can be obtained anywhere within the range of the 96 in. obtained at two settings. All the sliding surfaces are provided with oil boxes in the castings and the oil is fed on to the sliding ways by wicks, while the bearings that run continuously are fed with oil by drip feed from a central supply, and the bearings for the intermittent motion have telltale grease cups. After setting the slides, locking is performed by T-slots and bolts of large dimensions. In order to provide for wear, all the sliding surfaces can be adjusted by tapered gibs and end thrust on the traversing spindle and facing chuck is taken on ball washers of large diameters.

The following are some of the leading particulars of the machine, all of which are given in the original article:

Diameter of drilling and boring spindle	8 in.
Traverse of drilling and boring spindle at one setting	48 in.
Maximum diameter machine will face	108 in.
Number of speeds to spindle and chuck	24
Vertical traverse of sliding head	8 ft.
Maximum distance, center of spindle to main table	9 ft. 6 in.

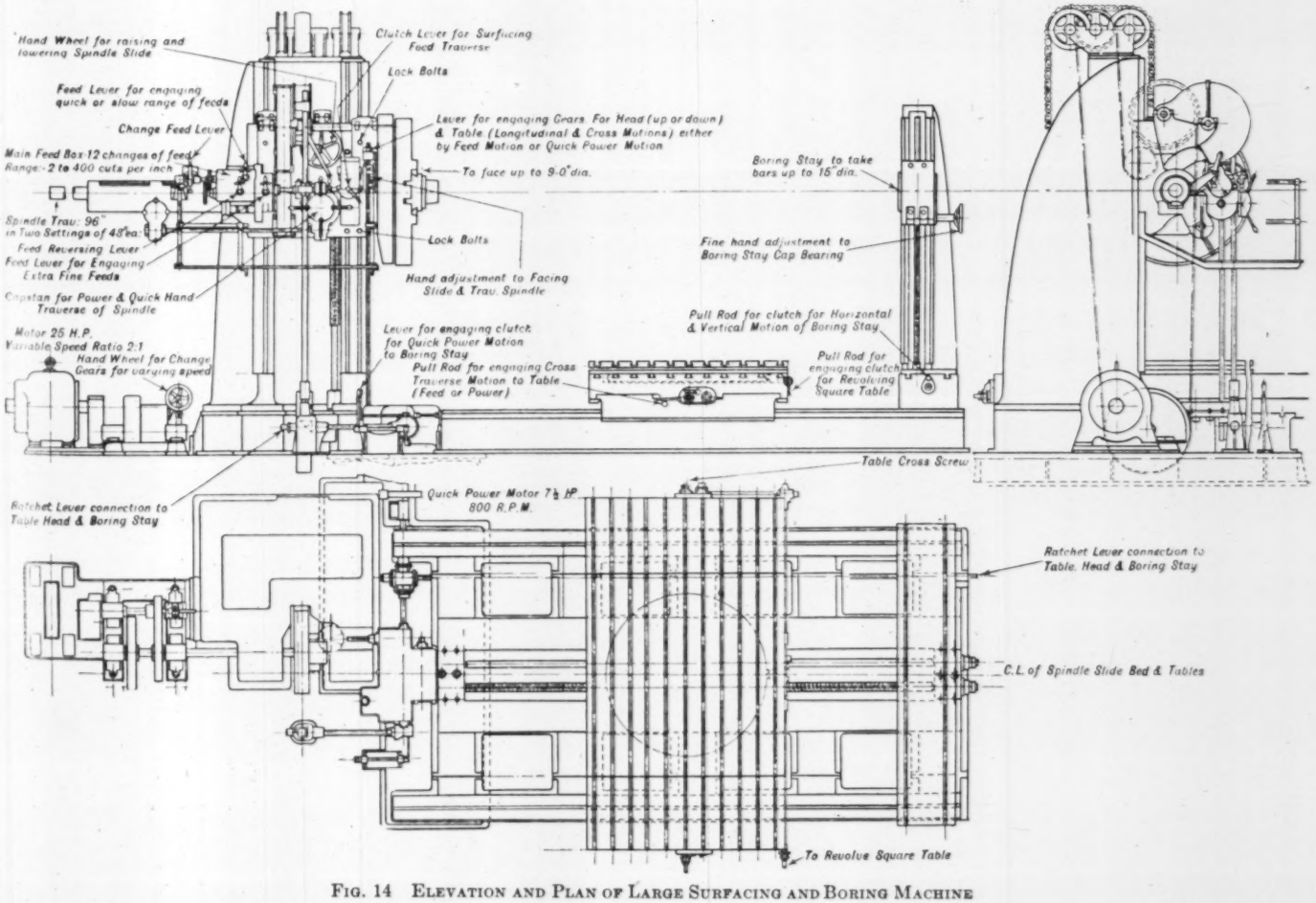

Hand Wheel for raising and lowering Spindle Slide
Clutch Lever for Surfacing Feed Traverse
Lock Bolts
Feed Lever for engaging quick or slow range of feeds
Change Feed Lever
Lever for engaging Gears For Head (up or down) & Table (Longitudinal & Cross Motions) either by Feed Motion or Quick Power Motion
Main Feed Box 12 changes of feed Range:- 2 to 400 cuts per inch
To face up to 9-0" dia.
Boring Stay to take bars up to 15" dia.
Spindle Trav: 96" in Two Settings of 48" ea:
Lock Bolts
Fine hand adjustment to Boring Stay Cap Bearing
Feed Reversing Lever
Feed Lever for Engaging Extra Fine Feeds
Hand adjustment to Facing Slide & Trav. Spindle
Capstan for Power & Quick Hand Traverse of Spindle
Pull Rod for clutch for Horizontal & Vertical Motion of Boring Stay
Motor 25 H.P. Variable Speed Ratio 2:1
Lever for engaging clutch for Quick Power Motion to Boring Stay
Hand Wheel for Change Gears for varying speed
Pull Rod for engaging Cross Traverse Motion to Table (Feed or Power)
Pull Rod for engaging clutch for Revolving Square Table
Table Cross Screw
Ratchet Lever connection to Table Head & Boring Stay
Quick Power Motor 7½ HP 800 R.P.M.
Ratchet Lever connection to Table Head & Boring Stay
C.L. of Spindle Slide Bed & Tables
To Revolve Square Table

FIG. 14 ELEVATION AND PLAN OF LARGE SURFACING AND BORING MACHINE

Size of main table	108 in. by 96 in.
Size of detachable turn-table	96 in. by 96 in.
Longitudinal traverse of table	144 in.
Maximum diameter of bar machine will take	15 in.

The machine is driven by a 30-b.hp. electric motor, while a separate motor is fitted for operating the rapid power traverse motion. All the motions are controlled from the platform attached to the spindle slide, and duplicated control gear of the "push button" type is fitted for operation from the most convenient positions. Reversing to all motions except the feed, which is mechanical, is obtained electrically. (*The Engineer*, vol. 134, no. 3484, Oct. 6, 1922, pp. 360–361, 3 figs., *d*)

MECHANICS

New Principles in Rotative Balance, Amos F. Moyer, Mem. Am.Soc.M.E. Description of the balancing machine designed on the basis of principles evolved by Dr. B. L. Newkirk, of the General Electric Co., which makes it possible to measure directly the resultants for the two separate ends of a rotative body and to locate them without the necessity of separating the standing from the running balance. (*Journal of the Society of Automotive Engineers*, vol. 11, no. 4, Oct., 1922, pp. 368–372, 9 figs., *d*)

METALLURGY (See also Engineering Materials)

The Decarburization of Ferrochromium by Hydrogen, L. Jordan and F. E. Swindells. The recently developed "rustless" iron may be considered as stainless steel from which the carbon has been largely eliminated. The carbon content of rustless iron is in the neighborhood of, or less than, 0.1 per cent. In order to produce an iron alloy containing as high as 12 per cent chromium and still keep the carbon content as low as indicated, it is necessary to use ferrochromium lower in carbon than the more common commercial grades bearing 4 to 8 per cent carbon. Carbon-free ferrochromium made by aluminothermic methods is available, but at prices which are too high to allow its extended use in producing rustless iron.

Various procedures for decarburizing high-carbon ferrochromium have been described in a number of patents. The decarburization of ferrochromium by means of hydrogen has been suggested. The decarburization of cast iron and steels by heating in hydrogen at temperatures between 400 and 1200 deg. cent. has been described previously. Tests carried out on 60 per cent ferrochromium containing 8 per cent carbon showed that there was a slow decarburization of the powdered ferroalloy by dry hydrogen between 1100 and 1350 deg. cent. The removal of carbon was more rapid just above than below the melting point of the alloy. The most rapid decarburization was secured by bubbling hydrogen through molten ferrochromium at approximately 1500 deg. cent. Under these conditions nearly 1 per cent of carbon was removed from the alloy in four minutes as compared with four hours required to reduce the carbon 1.6 per cent at a temperature just below the melting point of the alloy. The most promising condition for refining high-carbon ferrochromium by this method is probably blowing the alloy with a blast of hydrogen in a converter. (Technical Abstract of *Scientific Papers of the Bureau of Standards*, no. 448, *d*)

MOTOR-CAR ENGINEERING (See also Gas Producers)

Frameless Lancia Chassis, W. F. Bradley. Description of a unit where the body made from sheet-metal stampings is so designed as to require no chassis frame. This has been already illustrated and briefly commented on in Mechanical Engineering, vol. 42, no. 9, Sept., 1920, p. 525.

By means of this design the weight of a four-passenger car with phaeton body and full equipment has been reduced to the unheard-of figure of 1650 lb., which is all the more remarkable from the fact that the car has a wheelbase of 122 in., track of 43 in., speed ability of 70 to 75 m.p.h. on the level, and a reputed gasoline consumption of 21 miles to the American gallon. This was done by eliminating frame members and the usual type of body construction with heavy body sills. The body is built up of two main pressed-steel side members having a thickness of 2 mm. These members are united by a series of cross-members formed into the following units: radiator housing, toe board and scuttle dash, frame and back rest of front seat, etc. From the toe board to the rear-seat back rest there is a longitudinal tunnel which receives the propeller shaft. The top of the tunnel is cut away just ahead of the front seat for the brake and change-speed levers to be passed through.

When the necessary dies and presses have been installed the Lancia type of construction is claimed to be very much cheaper than normal body building with its attendant chassis frame. The engine used on this car is a four-cylinder V-type with an angle of 20 deg. In addition to forming a V, the cylinders are in staggered relation. This disposition avoids the use of forked connecting rods and gives a separate bearing for each rod.

Instead of the usual type of forged axle, Lancia has a triangular steel-tube construction comprising a bottom horizontal tube uniting the radiator housing and the steering yokes, two tubes from the top of the steering yokes to the top of the radiator housing, and another pair from the bottom of the steering yokes to a point on the main frame on a line with the dash. Front suspension is by means of a system of enclosed coil springs and hydraulic shock absorbers, the cylinders for the hydraulic system serving also to house the coil springs. The front-wheel brakes are operated by pedal in conjunction with those on the rear wheels. A feature of the front-wheel brakes is that the drums are within the wheels, the center line of the drums almost coinciding with the center line of the tire. Aluminum drums with die-cast aluminum shoes are employed. (*Automotive Industries*, vol. 67, no. 15, Oct. 12, 1922, pp. 706–708, 3 figs., *dA*)

OIL ENGINEERING

Design and Operation of a Low-Pressure Absorption Plant, W. P. Dykema and A. A. Chenoweth. This report, which can only be referred to here in a very general manner, gives a detailed outline of an experimental plant installed in the Cushing oil field in Oklahoma and of its regular operation, together with records of temperatures, pressure, production, and changes in equipment. It also considers data on the latent heat of absorbed gases and a proposed means of overcoming the increase in temperature of the oil as it circulates through the towers.

In the opinion of the authors a low-pressure absorption plant can easily recover all the valuable gasoline fractions from rich casing-head gas if the absorption oil and the gas being absorbed are kept at a temperature not higher than 80 deg. and not necessarily less than 70 deg. fahr. This temperature range must be maintained throughout the absorbing process, from the time the oil and gas first come into contact until each, separated, leaves the absorption towers on its way through the plant. It is certain, however, that the more closely the temperature is held to the lower value, the more satisfactory and complete is the cleaning of the gas from all marketable gasoline. Data not fully set out in the report confirm this statement and a table given illustrates it by showing an air temperature of 58 deg. fahr. and an oil temperature of 81 deg. as it starts through the absorbers. The increase of 20 deg. fahr. in added heat, by reason of the latent heat of the absorbed gases, here 20 per cent of the total, is therefore of great importance. (*Bureau of Mines Technical Paper 263*, 1922, 40 pp., 14 figs., *ep*)

PHYSICS (See Power-Plant Engineering)

POWER-PLANT ENGINEERING (See also Fuels and Firing; Railroad Engineering)

Application of the Stefan Law to the Calculation of Furnaces, Prof. Vicente Burgaleta. The author presents the general theory of radiation and develops formulas for the expression of the Stefan law, which he proposes to apply to the calculation of furnaces. In the first part of the article he establishes the experimental bases for the calculation of emission and absorption of radiant heat, using methods not generally employed in engineering literature, and from these, by an analytical method, he establishes the precision and limits of the Stefan law. In the second part he shows how the Stefan law may be applied to the calculation of furnaces and then compares results obtained by this method, in

particular on locomotive furnaces, with values generally known. The article is of a mathematical character and not suitable for abstracting. (*Anales de la Asociacion de Ingenieros del Instituto Catolico de Artes e Industrias*, vol. 1, no. 1, Jan., 1922, pp. 39–45, 5 figs., *pmA*)

THE EFFECT OF POLARIZED MERCURY ON BOILER TUBES, Geo. L. Fowler, Mem. Am.Soc.M.E. Data of an investigation made as to the characteristics of the film produced in boiler tubes by the boiler compound known as "polarized mercury." It is not stated where and by whom this investigation was made.

It is stated that the film as it was found on the tube was a smooth glossy black, much smoother than the original surface of the tube when new and having a slightly lustrous polish resembling that of Russia iron. It was exceedingly hard and brittle, very closely adherent to the metal beneath, and could only be removed with difficulty. It could not be peeled off and could only be separated from the metal by using a hard and sharp scraper, the removed material coming off in the shape of a finely divided powder. There were no flakes, for the brittleness of the material was such that any disturbance of it caused it to crumble.

The tube examined was partly covered with scale, but this could be easily removed by scraping it off with an ordinary scraper, leaving the tube clean and free from any adhering particles. When clean the tube was found to be almost entirely covered with the black film referred to above.

In the physical examination of the film it proved to be impossible to detect the presence of mercury microscopically. Chemical analysis showed that the film consisted of black magnetic oxide of iron (Fe_3O_4) and some ferric oxide (Fe_2O_3), together with a small amount of free mercury present, which was, however, a mere trace. The amount of ferric oxide present was also very small. The protective properties of the film are ascribed to the presence of magnetic oxide of iron and a theory is offered to account for the formation of the black magnetic oxide, and the role played in this process by previous deposits of scale. (*Railway and Locomotive Engineering*, vol. 35, no. 10, Oct., 1922, pp. 255–257, 10 figs., *dg*)

UNDERFEED STOKERS OF THE DETROIT EDISON CO., E. E. Dubry. Description of a 13-retort underfeed stoker with a total grate area of 470 sq. ft., which makes possible a big reduction in the number of overhead bunkers and coal-conveying equipment.

For some time the Detroit Edison Co. has desired to see what could be done with a long stoker feeding the furnace from one side only, as with this scheme it would become possible to reduce the cost of the boiler unit by reducing the number of overhead bunkers from three to one. The introduction of the so-called superstoker (a stoker having long retorts and the dimensions increased to permit the necessary high rates of coal feed) by the Sanford Riley Stoker Co. afforded an opportunity to try out the single-end arrangement of stoker and furnace.

In general design this stoker does not differ materially from the standard Riley type, but the entire mechanism is larger and heavier throughout. There are thirteen retorts, fed by rams 11 in. in diameter having a stroke of 12 in., giving a piston displacement nearly 80 per cent larger than that of the 9-in. ram having a 10-in. stroke, so that with the crankshaft running at a slightly higher speed these thirteen rams feed coal as rapidly as do the twenty-six retorts of the double-ended stoker.

The outstanding feature of this particular type of stoker is that the tuyeres or grate blocks are movable in a direction parallel to the path of the coal. The length of travel is adjustable and under control of the operator, but the period of oscillation is dependent upon the stoker speed, since each complete tuyere box, from the point where coal enters to the end of the apron at the clinker grinder, is driven by its corresponding ram.

No complete test of the unit has yet been made, but various preliminary observations lead to the belief that the work of the two sides of the boiler is quite evenly distributed since the gas temperature at the beginning and end of each half are practically the same, likewise the temperatures of the steam leaving each superheater. The stoker responds quickly in an increase in the rate of combustion and can pick up load as rapidly as the double-ended units. (*Power*, vol. 56, no. 14, Oct. 3, 1922, pp. 536–538, 5 figs., *d*)

RAILROAD ENGINEERING (See also Engineering Materials; Power-Plant Engineering)

STEAM-PROPELLED UNIT RAILWAY MOTOR CAR. Description of the type recently placed in service on the Canadian National Railways, and built by the Unit Railway Car Co., Boston, Mass.

The car has a water-tube boiler and an oil burner. The power plant embodies the principles used in the Stanley steam automobile and is built under the same patents. In the first run from Boston to Toronto it covered without any trouble the distance of 660 miles with a running speed for much of the distance of between 45 and 55 m.p.h. The body of the car is of steel construction and the car is equipped with standard couplers. The trucks are of a modified arch-bar pedestal type of light construction. The car is designed for single-end operation, but may be driven at equal speed in either direction. The light weight of the car complete is 59,000 lb., of which 13,000 lb. is for the power plant complete with all auxiliaries.

The boiler is of the water-tube type and is made in 12 sections, being constructed throughout of seamless boiler tubes. Each section consists of a front and back vertical header, the two being joined by 22 water tubes inclined at about 11 deg. to the front header and a single connecting steam tube at the top inclined at about 1 deg. to the back header. All tubes are straight and are electrically welded to the headers; opposite each end of every tube an opening is provided in the headers through which the tube can be inspected, cleaned, or, in case of rupture, can be temporarily plugged.

The construction of the steam drum and connections is such that they act as a desaturator. From the steam drum the steam passes through the superheater in series, an arrangement which has been found to increase materially the life of the superheater unit.

The steam pressure ordinarily carried is about 80 lb. per sq. in., while the ultimate temperature after passing through the superheater is from 650 to 800 deg. fahr. The car is propelled by a simple two-cylinder engine mounted on the front side of the forward truck, power being transmitted to the axle by a single spur gear pressed on to the center of the axle.

The high-pressure superheated steam is carried from the throttle to the engine by a flexible pipe, while the exhaust steam from the main and auxiliary engines is conducted to an air-cooled condenser located on the roof of the car at the forward end. The auxiliary steam engine just referred to drives the two feedwater pumps, the fuel-oil pump, duplex-cylinder lubricating-oil pump, and the 2-kw. d.c. generator. This engine is run at constant speed and governed by a ball-type governor.

Records taken from cars in service show an average consumption of approximately 0.7 gal. of distillate, or 0.65 gal. of kerosene per car-mile. At the low price at which distillate can be obtained in many places, this represents a fuel cost of about four cents per car-mile. For lubricating purposes two gallons of a special cylinder oil has been found to be sufficient for a 400-mile run and one gallon of engine oil for the same mileage.

The mechanical efficiency in the main engine and drive is high. The boiler efficiency when using superheated steam at 700 to 800 deg. fahr. at the atomizer is said to be about 77 per cent. The time required to generate steam with storage air for the atomizer is from 20 to 25 min., and with steam at 200 lb. pressure, approximately 18 min. An evaporation of about 14 lb. of water from and at 212 deg. fahr. may be obtained per square foot of wetted heating surface. The main engine uses from 14 lb. to 19 lb. of water, depending upon load and grade conditions, to develop one horsepower-hour. (*Railway Age*, vol. 73, no. 16, Oct. 14, 1922, pp. 711–713, 5 figs., *d*)

Locomotive-Type Steam Desaturator

STEAM DESATURATORS ON HUNGARIAN RAILROADS, Desider Ledacs Kiss. Until very recently steam desaturators have been only experimentally applied to American locomotives, but as large-diameter boilers and limited overhead clearance in modern locomotives are making it increasingly difficult to elevate the throttle sufficiently above the water level to insure dry steam, such devices are becoming of interest in connection with locomotive design in this country.

The Stein desaturator has been recently applied to approximately 1000 locomotives on the Hungarian State Railways. The principle of this device is based on the fact that water which has a higher specific weight may be separated from the steam flowing to the throttle by the centrifugal force resulting from a sudden reversing in the direction of the steam flow. The unrestricted return of the separated water is secured by means of a water seal or siphon device. The desaturator therefore consists of two principal parts—the separator and the water seal. The separation of moisture from the steam by means of centrifugal force is effected before the steam flows into the throttle by directing the steam through an intercepting port which is curved into a small radius. In this curved passage the small particles of moisture due to centrifugal force are hurled against the plate constituting the outer radius of this passage. This separation of moisture from the steam is further effected in a chamber joining the curved intercepting port where the steam suddenly reversed its direction and simultaneously diminishes its velocity so that the particles of moisture fall to the bottom of the chamber. The water separated from the steam flows back into the boiler through a siphon which also constitutes a water seal, while the desaturated steam flows upward to the throttle valve.

The device is relatively inexpensive to construct, has no moving parts, and, it is said, its maintenance is practically negligible.

Tests have shown that the performance of a locomotive equipped with the desaturator is superior to that without it, and that locomotives equipped with desaturators require 25 per cent less cylinder oil for lubrication than locomotives operating without desaturators.

The peculiar type of balanced slide throttle valve was designed for use in conjunction with desaturators. The double-beat throttle valve commonly used on American motive power is rarely used in Europe, the objection to this type being the liability of the valve to leakage in bad-water districts owing to the incrustation of scale deposited on the valve seats.

The partially balanced slide valve of a type used on the Hungarian State Railways is shown in Fig. 15.

This throttle consists of two slide valves as shown, (*a*) being the main slide valve while the easing valve (*c*) has a limited travel. The latter is operated by a lever (*k*), so that in opening the throttle lever this easing valve is first moved to the point where the slot (*e*) coincides with the slot (*c*) in the main slide valve, when steam is admitted to the dry pipe, thus balancing the pressure on the main slide valve. As the main valve is opened, the easing valve moves with it, but in the meantime the easing valve has served to admit a small quantity of steam so that a sudden inrush of steam to the cylinders is avoided. Another advantage of the easing valve is found in the light running of the locomotive and in drifting when it is desirable to keep a small quantity of steam in the cylinders for the purpose of better lubrication, particularly where the steam is superheated. Under these conditions the easing valve will alone supply sufficient steam to keep the piston-valve and cylinder surfaces well lubricated, thus obviating the practice of running with a "cracked" throttle ordinarily employed with the double-beat throttle valve. (*Railway Review*, vol. 71, no. 15, Oct. 7, 1922, pp. 475–478, *d*)

REFRIGERATION

FEATHER-VALVE COMPRESSORS OF THREE TYPES, CONSTRUCTION AND OPERATION, F. L. Fairbanks, Mem. Am.Soc.M.E. Paper based on the experience of the author with the apparatus at the Richmond Street Station of the Quincy Market Cold Storage and Warehouse Company, Boston, Mass.

In order to meet increased load conditions which proved to be in excess of original expectations, the speed of the (Boyle) compressors at the plant was increased from time to time until one of over 70 r.p.m. had been reached. It was found that while the capacity was thereby augmented it did not increase in proportion to the increase in speed, this being ascribed to lag in the operation of the poppet valves and to the excessive inertia of the heavy reciprocating parts which began to tell at the increased speeds.

In order to meet these conditions rather than with an idea of increased economy, it was decided to install a booster which consisted of a steam-driven, twin-tandem, enclosed-crankcase, feather-valve air compressor designed to deliver air at 75 lb. per sq. in., the only changes being made to adapt it for ammonia, aside from using a somewhat heavier flywheel, being in the stuffing boxes and a few other minor details.

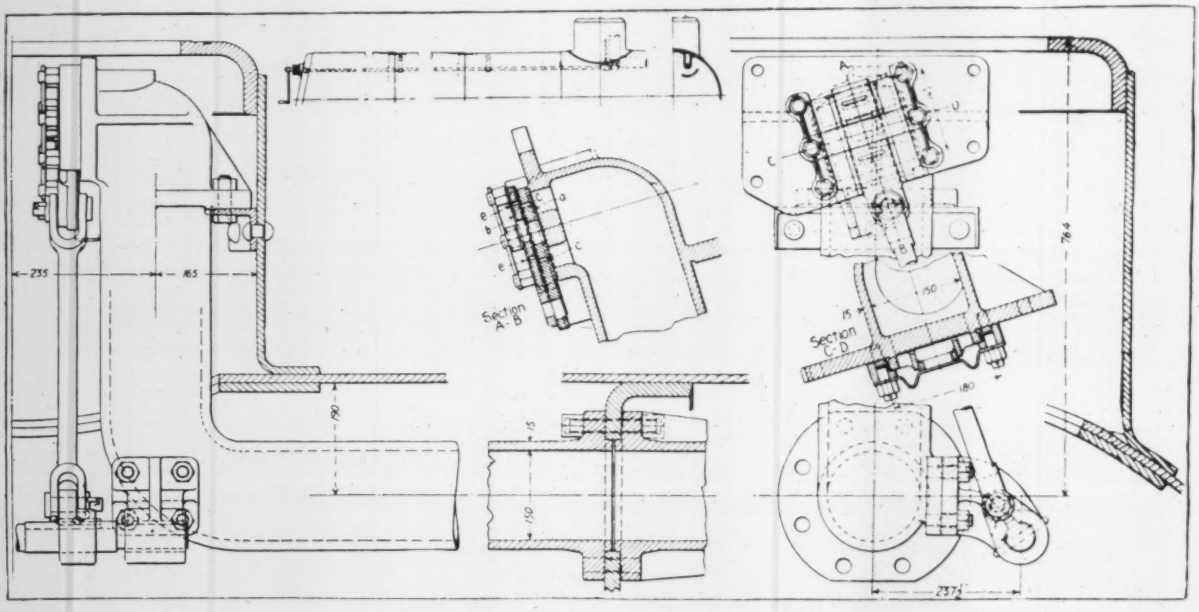


FIG. 15 STRUCTURAL DETAILS AND METHOD OF APPLYING SEMI-BALANCED SLIDE-VALVE THROTTLES TO LOCOMOTIVES OF THE HUNGARIAN STATE RAILWAYS

In operating this booster, steam was taken from the mains at 125 lb. per sq. in. pressure, superheated 100 deg. fahr., and the exhaust was delivered to the intermediate steam receiver between the high- and low-pressure cylinders of the larger compressor. In other words, the steam end of the booster was compounded with the steam end of the larger compressor with a view to getting the best economy possible under the conditions.

The method of operation was to operate the large compressor at a constant speed of 40 r.p.m.—approximately the builder's rating—at which speed the valves and reciprocating parts functioned without distress, and to operate the booster at a speed necessary to produce the tonnage required; this change of speed in the booster being accomplished by varying the Meyer cut-off to meet the local conditions, up to a maximum speed of 300 r.p.m.

It was expected that this booster, at an expense of about one-twelfth of the cost of the larger machine and with a very limited

floor space available, would double the capacity of the larger compressor at its rated speed.

Operation has shown that the expected has been easily exceeded and, while this was probably the first application of the feather-valve compressor to ammonia service, it has been one of the most pleasing and most satisfactory pieces of apparatus in the equipment of the plant.

A cross-compound or two-stage synchronous-motor-driven machine is also described. Tests were conducted and the resultant data show the advantages of compound compression.

Another installation, in which two old slow-speed single-acting vertical compressors and two absorption machines were removed to accommodate a new uniflow-steam-engine-driven compressor, is described. This installation, as well as the other two already mentioned, was tested to ascertain its efficiency. (*Refrigerating Engineering*, vol. 9, no. 3, Sept., 1922, pp. 85–92 and 94, 101–102, 11 figs., *deA*)

SHIPBUILDING

THE FLETTNER RUDDER. A new type of rudder which is said to have already been fitted to one or two vessels of moderate size and will be installed on the *Odenwald*, an 8000-ton twin-screw motor vessel now being built for the Hamburg-American Line.

The rudder is based upon the well-known principle that when a rudder is turned in a moving stream of water such as is produced by the propeller there is caused a difference of pressure on the two sides. In the Flettner arrangement the rudder consists of a main and auxiliary rudder, the latter having usually only in the neighborhood of one-twentieth of the surface of the former. The power required to turn it is comparatively small, and the pressure difference created is therefore utilized automatically to cause the movement of the main rudder. By a suitable means a small vertical shaft within the rudder spindle is operated by hand from the bridge. At the bottom of the shaft an attachment is made to a short beam carrying two parallel links the opposite ends of which are attached to a similar beam carrying the auxiliary rudder. This is, of course, capable of swinging independently of the main rudder. It is claimed (says the *Motor Ship*) that although the area of the auxiliary rudder may be 5 per cent of that of the main rudder, the power required for its operation is actually only between 2 and 3 per cent of that which is needed for actuating a rudder in the ordinary way.

On the motorship *Odenwald* the spindle actuating the auxiliary rudder is operated from the bridge by means of steering cable of a size normally used on a small boat with hand steering gear. There is also an emergency gear, enabling the rudder to be operated in the ordinary way, either by hand or from a steam windlass on deck. It should be noted that when the engines are reversed and the vessel goes astern the rudder swings right round through an angle of 180 deg.

The Flettner rudder, which is attracting the utmost attention in Germany, is the outcome of prolonged experimental work, while the principle was adopted in connection with airplanes during the war. Although the *Odenwald* represents the first large ship on which it will be fitted, it has been adapted to the small Dutch steamer *Frigido*, a vessel of about 210 tons gross. For many months past this vessel has been in operation with the rudder, which, it is stated, is operated by hand with a steering wheel no larger than a motor-car steering wheel. The steering wire in this case is said to be only 4 mm. in diameter, and it is reported that in heavy weather and in crowded waters it has always proved extremely successful. (*The Practical Engineer*, vol. 66, no. 1858, Oct. 5, 1922, p. 222, *d*)

STEAM ENGINEERING (See Railroad Engineering)

TESTING AND MEASUREMENTS

X-RAY EXAMINATION OF INNER STRUCTURE OF STRAINED METALS, CHIEFLY COPPER WIRES, Prof. Akimasa Ono. Data of experiments wherein X-ray interference figures obtained from several copper wires are reported with special regard to the crystal arrangement in the strained copper. Experiments show that a copper rod composed of an irregular mass of small crystals on being drawn into wire takes a fibrous structure, the arrangement of crystal lattices being transformed into a state of axial irregularity. This may perhaps account for the changes in such properties as hardness and strength.

By finding the inclinations of several simple planes in the face-centered cubic lattice and calculating the relative intensity of rays reflected by the planes, it was shown that a group of this kind of lattices with the trigonal axis in the longitudinal direction of the specimen gives rise to the pattern obtained in the experiment.

The author believes that it is probable that the trigonal axis coincides with the longitudinal direction or the fiber direction of the specimen, and whether this is really the case may be tested by a spectrographic investigation which is now being arranged for. (*Memoirs of the College of Engineering, Kyshu Imperial University*, Fukuoka, Japan, vol. 2, no. 5, 1922, pp. 241–260 and 5 plates of illustrations, *e*)

THERMODYNAMICS (See Power-Plant Engineering)

VARIA

A NEW SCULPTURING METHOD, W. F. Engelmann. This new method consists of two separate steps: the recording of the form of the object, and the carving out of the reproduction.

The recording is done by means of a moving-picture camera equipped with a black shade movable through worm and worm wheel in such a manner that only a part of the object is illuminated. To record a face, for example, the shade is first placed so that only the tip of the nose is projecting into the light and gradually drawn back until the entire face is exposed to the camera. In this way a number of photographs are obtained, the outline of each new picture giving the contour of a different plane of the object and each picture being slightly different in size from its neighbors on both sides.

The second step, which is the carving out of the reproduction, is a simple machining operation in which the reproduction is milled out in as many planes as there were contour pictures made of the object. Each plane of the reproduction has its own contour picture which is used as a pattern from which to copy the contour of a plane. The outline of the contour picture is transferred to its plane by a pantograph which holds in its one free end a tracer disk and in its other free end a milling cutter.

Several modifications of the plane are described in the booklet. No data are given to show whether actual machines have been built on the plan described, and what results have been obtained. (Pamphlet published by author, Chicago, Ill., 1922, 35 pp., 6 figs., *g*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reveiwer. Opinions expressed are those of the reviewer, not of the Society.

Addendum to Table of the Torsional Strength of Bars

The following should be added to the table of the Torsional Strength of Bars published in the November, 1922, issue (pp. 738, 739, 740) of MECHANICAL ENGINEERING.

In the table in question:

G = modulus of rigidity
δ = angle of torsion in a given length.

The value of ψ are, as follows:

n =	1	1.5	2	3	4	6	8	10	∞
ψ_1 =	0.6753	0.8476	0.9300	0.9854	0.9970	0.9999	—1	—1	1
ψ_2 =	0.6753	0.7279	0.7395	0.7423	0.7423	0.7425	0.7425	0.7425	0.7425
ψ_3 =	0.1404	0.1957	0.2286	0.2633	0.2808	0.2982	0.3070	0.3123	0.3333
ψ_4 =	4.81	4.33	4.07	3.74	3.55	3.35	3.26	3.20	3.00
ψ_5 =	0.1539	0.1362	0.1318	0.1357	0.1412	0.1491	0.1535	0.1562	0.1667
ψ_6 =	0.1472	0.2015	0.2277	0.2454	0.2491	0.2500	0.2500	0.2500	0.2500

Test Code for Reciprocating Displacement Pumps

Preliminary Draft of the Eighth in the Series of Nineteen Test Codes Being Formulated by the A.S.M.E. Committee on Power Test Codes

THE Committee on Power Test Codes is now engaged in the revision of the A.S.M.E. Test Codes of 1915. Mr. Fred R. Low is Chairman of the Main Committee of twenty-five which guides the work of the nineteen Individual Committees. Below is reproduced the eighth of these codes to be completed. The Individual Committee which developed this Code is headed by Mr. D. A. Decrow as Chairman and consists of C. H. Anderson, E. H. Brown, G. J. Foran,[1] and L. E. Strothman. Mr. Strothman was Chairman of the Committee from the time of its organization in December, 1918, until his death in May, 1922.

The Committee and the Society will welcome suggestions for corrections or additions to this draft of its Code from those who are especially interested in the manufacture and testing of Reciprocating Displacement Pumps, whether driven by steam, gasoline, electric, or other forms of motive power. These comments should be addressed to the chairman of the Committee in care of The American Society of Mechanical Engineers.

Introduction

1 The code for reciprocating steam pumping machinery applies to tests for determining the performance of the pump and engine, including reheaters, heaters and jackets, if any, and jacket pumps, circulating pumps, condensate pumps and vacuum pumps which are concerned in their operation. For tests of pumping machinery and boiler plant combined, reference should be made to the Code for Complete Steam Power Plants.

Object

2 In accordance with the "General Instructions" the object of the test should be determined and recorded. If the object relates to the fulfilment of a contract-guarantee, an agreement should be made between the interested parties concerning all matters about which dispute may arise, as noted in Par. 3 of the "General Instructions," and the points agreed upon should be stated in the Report of the Test.

Measurements

3 The fundamental measurements that must be made in a duty trial of a reciprocating steam pumping engine are:

(*a*) Amount of water pumped, in pounds
(*b*) Average head, in feet
(*c*) Amount of steam consumed, in pounds; or the amount of heat consumed, in B.t.u.

In addition to the above, the following principal data are to be determined:

(*d*) Diameter and stroke of plungers and rods
(*e*) Diameter of steam cylinders and piston rods
(*f*) Stroke of the steam pistons
(*g*) Speed, in revolutions
(*h*) Indicated horsepower of steam and water cylinders
(*i*) Steam pressure at throttle in pounds per square inch above atmosphere
(*j*) Atmospheric pressure in inches of mercury
(*k*) Quality of the steam (moisture or superheat at the throttle)
(*l*) Exhaust pressure in pounds per square inch above zero, or vacuum in inches of mercury
(*m*) Receiver pressures in pounds per square inch
(*n*) Temperature of the exhaust steam.

Instruments and Apparatus

4 The instruments and apparatus required for a performance test of a reciprocating displacement pump are:

(*a*) Tanks and platform, scales for weighing the quantities of condensed steam, leakage water or boiler feedwater in accordance with the object of the test and local conditions
(*b*) Graduated scales attached to the water glasses of the boiler, if the feedwater is measured; the elevation of zero mark of the graduations being fixed and recorded with reference to some part of the gage-glass fitting which will not be moved or altered by the destruction and renewal of the glass
(*c*) Pressure gages, vacuum gages and thermometers provided with suitable mercury wells
(*d*) Steam calorimeters
(*e*) Barometer
(*f*) Revolution counter or other accurate speed-measuring device
(*g*) A venturi meter or other means for measuring the quantity of water pumped
(*h*) Graduated stroke scales for direct-acting pumps
(*i*) Indicators for the steam and water cylinders
(*j*) A planimeter
(*k*) A dead-weight gage tester.

Directions regarding the application, use, and calibration of the instruments and apparatus noted and statements as to their accuracy are given in Paragraphs Nos. .... of the "Code on Instruments and Apparatus."

The gage on the discharge main should be attached near the pump discharge nozzle, and that on the suction main near the suction nozzle. The gage pipes should be provided with valves at the gages and pet-cock outlets on the pump side of their valves. The pet cocks should be occasionally opened to let out the air, if any, and fill the pipes with water when under pressure, or let in the air and empty them of water, if any, when under vacuum.

Preparations

5 Paragraphs 1 to 19 of the General Instructions should first be carefully studied. The dimensions of the pumps should next be determined and recorded, especially those of the plungers and rods. Note should also be taken of the physical conditions not only of the pumping machinery but of all parts of the plant concerned. The testing appliances may then be installed and the leakage tests conducted.

5a *Dimensions.* The dimensions of steam and water cylinders should be determined by methods described in the "Test Code for Reciprocating Steam Engines," Par. 5a

5b *Leakage of Engine.* The amount of leakage of the engine should be determined by weighing. There may be leakage through valves, past the piston or in the condenser. For approved methods of determining the amount of this leakage see Pars. Nos. .....of the "Code on Instruments and Apparatus."

5c *Leakage Test of Pump.* The tightness of the suction and discharge valves and the plunger packing, if it is of the inside-packed construction, should be ascertained by putting the specified discharge pressure on them and observing the leakage by removing a handhole or manhole cover on the suction side of the part being tested. If consistent with object in view, the valves should be made tight and the plunger packing should leak only enough to insure that the friction of the packing on the plunger is not excessive. The leakage past the valves and plungers should be measured by conducting the leakage water to weighing tanks or other measuring devices, such as a weir or orifice, which are suitable for the quantity to be measured, and the rate of leakage past each valve deck and plunger determined. In correcting the plunger displacement for the leakage thus found it should be remembered that each valve deck and single-acting plunger leaks during only one-half the period of the test. In the case of a direct-acting steam pump the rate of leakage can be determined by closing the main discharge valve, which must be proved to be tight, making certain that the plunger chamber and suction connections are filled with water and running the pump fast enough to keep the discharge-pressure at the normal test pressure. The rate of leakage as determined by this test may be deducted from the duty-test rate in computing the net quantity of water pumped.

6 *Water Rate.* The water rate or steam consumption of the engine should be determined by measuring the condensate from the surface condenser, if that type of condenser is in use, all the steam used by the engine and auxiliaries concerned passing into the condenser. If the condenser leaks, the defects causing such leakage should be remedied, or suitable leakage corrections should be made. The amount of condensation from jackets and reheaters as well as the steam used by the auxiliaries concerned, if not included in the condensate measurement, should be added thereto. If a surface condenser is not available, the steam consumption should be determined by feedwater tests, which require the measurement of the various supplies of water fed to the boiler. The water from separators and drips on the main steam line, the steam used for other equipment not a part of the engine under tests, and of the water and steam which escapes by leakage from the boiler

[1] Deceased.

and piping, must also be measured, and these quantities deducted from the total quantity of feedwater.

7 *Measurement of Water Pumped.* The quantity of water pumped should be determined by actual measurement, using a venturi meter, weir, orifice, or pitot tube, in accordance with the directions of the "Code on Instruments and Apparatus." This measurement should be checked by comparison with plunger displacement, corrected for plunger and valve leakage, the latter being determined as directed in Par. 5e. When the actual measurement cannot be obtained the plunger displacement method alone may be used. In direct-acting pumps the actual stroke of each plunger must be determined by the use of graduated stroke scales.

Operating Conditions

8 The operating conditions should conform to the object of the test and these should prevail throughout the trial, as pointed out in Par. 19 of the "General Instructions." Care should be taken that air is not snifted into the pump cylinders. In such cases where air enters in sufficient quantity to be revealed by the indicator diagrams from the pump cylinders or other means, the quantity of water determined by the plunger-displacement method must be corrected accordingly. If an air pump is used to remove air which enters the suction pipe in the supply system of the pumping engine, such a pump is not to be considered a part of the engine equipment so far as it concerns the test.

Starting and Stopping

9 The engine and appurtenances should be first thoroughly heated and run under the prescribed conditions until uniformity is secured. When surface-condenser measurement is used, a test for steam or heat consumption with substantially constant load should be continued for such time as may be necessary to obtain a number (not less than four) of successive hourly records, during which the results are reasonably uniform. Where the steam consumption is determined by measuring the feedwater to the boiler, the duration should be at least 5 hours, and preferably 10 hours.

9a When a surface condenser is used, the test should start by commencing to weigh or measure the condensate and any other quantities of steam consumption involved, at the same time beginning the regular observations and other necessary test work. At the end of the allotted time the test is stopped by discontinuing the measurements and observations. When feedwater measurements are employed, the test should be started by carefully observing the steam pressure and water level in the boiler, and the level in the feed tank, if measuring tanks are used, at the same time beginning the water measurements and taking up the regular work of the test. At the end of the prescribed time, the water levels and steam pressure should be brought as near as practicable to the same points as at the start, and the observations discontinued. If there are differences in the water levels or pressure, proper corrections must be applied to the water measurements.

9b When feedwater measurements are employed care should be taken in cases where the activity of combustion affects the height of water, that the same conditions of fire and draft are secured at the end as at the beginning. Care should also be observed to note the average height of water in the glass when the water line fluctuates.

Records

10 The general data should be recorded as pointed out in Pars. 20 to 30 of the "General Instructions." Instruments should be read and indicator cards taken from each end of each cylinder at least quarter-hourly when the conditions are uniform and oftener when there is much variation. By permitting the pencil to trace over the diagrams several times a pencil band will result, thus giving a better average than a single line for power measurement. If there are wide fluctuations in readings they should be shown by recording instruments. Each indicator card should be marked with the number, date, time, scale of spring and end of cylinder, and on one card of each set the readings of the steam gages should be recorded. The log should contain the record of the readings of steam and vacuum gages, thermometers, calorimeters, speed indicator, load-measuring devices, and all other instruments, and these readings should be obtained at practically the same time the indicator diagrams are made. The areas, length, mean effective pressures, and cut-offs shown by the indicator diagrams, should also be entered in the log. If complete test data are desired representative steam-pipe diagrams should be taken with an indicator applied near the throttle-valve gage and operated by connection to the reducing motion of the cylinder indicators.

10a A set of specimen indicator cards should be carefully selected from the whole number taken, and these should be embodied in the record. The specimen cards selected should be such as to show the average conditions of pressure and cut-off. If steam-pipe diagrams are obtained, specimens of these should also be placed in the record.

11 *Throttle Pressure.* The throttle pressure, or the average pressure in the steam pipe just before the throttle, is that shown by a corrected steam gage attached to the steam pipe $1^1/_2$ to 2 diameters from the throttle. Fluctuations in this pressure may be reduced by a moderate choking of the gage cock. When greater precision is desired or when the fluctuations in pressure are large the average pressure may be found by working up the steam-pipe indicator diagram taken at or near the same point, and finding the mean pressure for the entire stroke, during the periods of admission.

11a If the guarantee contract states that a certain steam pressure is to be maintained at the throttle, then the low part of the line should be used in determining the steam pressure.

Calculation of Results

12 *Water Rate.* Whether the engine is supplied with wet, dry and saturated, or superheated steam, the actual steam consumption is stated in the report of the test. When the engine is supplied with wet steam, the quantity of dry and saturated steam comprised in the wet steam is found by deducting from the total weight of steam as measured the moisture as shown by a calorimeter near the throttle. Superheated steam requires no correction. The "estimated steam" consumed corresponding to any desired or specified set of conditions as to moisture, superheat, pressure, and vacuum which differ from the conditions of the test—such, for example, as those required by a contract guarantee or acceptance test—should be determined in the manner previously agreed upon by the interested parties in accordance with Par. 3 of the "General Instructions." (See also Code on Definitions and Values, Par. 152, and Test Code for Steam Turbines.)

12a In view of the fact that "dry saturated steam" is practically unobtainable commercially and that the presence of moisture is detrimental to the economy of the engine to a greater degree than the amount present in the steam would indicate, arbitrary corrections (referred to in Par. 11 above) for correcting the actual water rate for quality are to be used in arriving at a value of "Estimated Steam."

13 *Heat Consumption.* The number of heat units consumed by an engine per hour is found by multiplying the consumption, as measured in pounds of steam per hour, by the difference between the total heat in one pound of steam at the average pressure and of the average quality found in the steam pipe near the throttle and the heat in one pound of water at the temperature of saturated steam at the average pressure existing in the exhaust pipe near the cylinder.

14 *Indicated Horsepower.* The indicated horsepower for *each end* of the cylinder is found by using the formula

$$\text{I.hp.} = \frac{PLAN}{33{,}000}$$

where P represents the mean effective pressure in pounds per square inch, L the length of the stroke in feet, A the area in square inches of the piston less the area of the piston rod, if any, and N the number of active strokes per minute. The total horsepower of a cylinder is the sum of the horsepower developed in the two ends.

14a The mean effective pressure should be found by dividing the area of the diagram in square inches as determined with a correct planimeter, by the length of the diagram in inches, and multiplying the quotient by the average corrected scale of the indicator spring. (The length of an indicator diagram is the distance between two perpendiculars to the atmospheric line drawn at the extremities of the diagram.) If a planimeter is not available, the approximate mean effective pressure may be determined by finding the average height of the diagram in inches as obtained by averaging a suitable number of ordinates, at least twenty, measured between the lines of the forward and return strokes, and then multiplying this average by the scale of the spring.

15 *Thermal Efficiency.* The proportion of the total heat consumption which is converted into work is called the "thermal efficiency," and is found by dividing 2545 (B.t.u. equivalent to 1 hp-hr.) by the number of heat units actually consumed per hp-hr. (Par. 13). The quotient is multiplied by 100 to express the thermal efficiency in per cent. The formula is:

$$\text{Thermal Efficiency} = \frac{2545}{w\,(H_1 - q_2)}$$

where w = pounds of steam as supplied per i.hp-hr.
H_1 = total heat above 32 deg. per pound of steam at the initial conditions prevailing before throttle valve.
q_2 = heat of liquid above 32 deg. in one pound of water at the temperature of saturated steam at exhaust pressure.

16 *Engine Efficiency.* The engine efficiency is the ratio obtained by dividing the heat equivalent of the actual work done by the heat available for an ideal engine. The accepted standard for the ideal steam engine is the Rankine cycle (Code on Definitions and Values, Par. 145). The engine efficiency is obtained by the following equation:

$$\text{Engine Efficiency (referred to i.hp.)} = \frac{2545}{w\ (H_1 - H_2)}$$

where w = pounds of steam as supplied per i.hp-hr.
H_1 = total heat above 32 deg. per pound of steam at the initial conditions prevailing before the throttle valve
H_2 = total heat above 32 deg. per pound of steam after adiabatic expansion from initial conditions to the final pressure.

H_1 and H_2 can be found from any Total Heat-Entropy diagram. $(H_1 - H_2)$ is the heat available for work per pound of steam.

17 *Head.* The head is determined from two elements, viz., the "discharge pressure," which is the pressure in the discharge main referred to the center line of the pump cylinders (or other datum line as may be determined on), and the "suction lift" or "suction pressure," which is the vacuum or pressure in the suction main referred to the same datum. When the suction main is under a vacuum the head is found by adding the "suction lift" to the "discharge pressure," both expressed in feet. When the suction main is under pressure the head is found by subtracting the "suction pressure" from the "discharge pressure," both expressed in feet.

17a *Discharge Pressure.* The discharge pressure is found by adding to the pressure in feet shown by the gage connected to the discharge main the vertical distance in feet between the center of the gage (if of the Bourdon spring type) or the lower surface of the mercury (if of the mercury type) above the center line of the pump cylinders (or other datum determined on). Should the gage be located below the datum line this distance is to be subtracted instead of added.

17b *Suction Lift.* The suction lift is found by adding to the pressure in feet shown by the vacuum gage connected to the suction main the vertical distance in feet between the datum line noted and the point where the gage pipe connects to the main. Should the vacuum gage be located above the datum line, this distance is to be subtracted instead of added.

17c *Suction Pressure.* The suction pressure, which obtains in cases where the suction pipe is under pressure, is found by subtracting the vertical distance in feet between the datum line and the center of the gage on the suction main (if of the Bourdon spring type) or the lower surface of the mercury (if of the mercury type) from the pressure in feet shown by the suction gage.

17d *Velocity head.* If there is a material difference in the velocities at the discharge and suction gage connections to the mains, the head should be corrected for the difference in the velocity heads in the two mains.

If there is a material difference in the velocities at the discharge and suction gage connections to the mains, the head should be corrected for the difference in the velocity heads in the two mains.

18 *Leakage of Pump.* The percentage of leakage in a reciprocating pump is found by dividing the quantity of leakage during the test, as computed from the rate of leakage determined on the leakage trial, by the plunger displacement during the test, and multiplying the quotient by 100.

19 *Capacity.* In cases where the water discharged is not otherwise measured, the capacity in gallons per 24 hours is found by multiplying the net area in square feet of all the plungers by the length of the stroke in feet, the number of discharge strokes per minute, the constant 1440 and the constant 7.48, and deducting the total pump leakage in gallons per 24 hours.

20 *Water Horsepower.* The water horsepower is found by multiplying the weight of water discharged, in pounds per hour, by the head, in feet, and dividing the product by 1,980,000.

21 *Duty per 1000 Lb. of Steam.* The duty in foot-pounds of work done per 1000 pounds of steam is found by multiplying the number of pounds of water discharged by the pump during the test, by the head in feet, dividing the product by the number of pounds of steam consumed during the test, and multiplying the quotient by 1000.

22 *Duty per 1,000,000 B.t.u.* The duty in foot-pounds of work done per 1,000,000 B.t.u. is found by multiplying the number of pounds of water discharged by the pump during the test by the head in feet, dividing the product by the number of B.t.u consumed, and multiplying the quotient by 1,000,000.

23 *Friction and Mechanical Efficiencies.* The *percentage of total friction* is found by subtracting from the average i.hp. of the steam engine the average water horsepower (Par. 20) and dividing the remainder by 100 times the engine i.hp. The *combined mechanical efficiency* of the entire engine is found by dividing the water horsepower (Par. 20) by the engine i.hp. and multiplying the quotient by 100. The *mechanical efficiency of engine and pump* is found by dividing the average pump i.hp. by the average engine i.hp. and multiplying the quotient by 100. The *hydraulic efficiency of the pump* is found by dividing the average water horsepower (Par. 20) by the average pump i.hp. and multiplying the quotient by 100.

24 *Correction Factors for Duty and Economy.* The correction factors to be applied when the conditions as to pressure, quality of steam, or vacuum differ from those desired or required, should be based so far as practicable on data determined from the engine itself. For example, the effect of a variation of pressure from that desired may be determined by making two additional tests at pressures 5 lb. and 10 lb., respectively, below that of the main test, plotting the results, and obtaining a curve of performance, on the basis of which the correction may be applied.

On tests conducted to determine if economy (heat and steam consumption) guarantees have been met, it is often necessary, and on tests for other purposes it is frequently desired, to estimate the performance of the steam end under conditions of steam pressure, quality (moisture or superheat) and vacuum different from those prevailing and obtainable during the tests. It is not feasible to give correction factors for a variation of conditions, but for steam pressure and vacuum (or back pressure) which can be readily varied over a considerable range, any necessary correction factor can be approximated closely by running a series of preliminary tests covering a range of pressures and plotting the computed economies as a function of the variable factor.

A variation of superheat in a plant is not ordinarily so readily effected, but by manipulating the rate at which the boilers are fired, a series of variable superheat tests can often be obtained and a correction factor experimentally determined. It is not considered practicable in test work not conducted for research purposes to determine the effect of moisture in the steam on the economy of the engine, but because of the fact that it is believed that moisture in the steam is more unfavorable to the economy than is indicated by the percentage of moisture present, it is important that any correction for moisture should cover but very minor variations in the quality. Further, since the first ten degrees of superheat affect the economy more favorably than the second ten degrees, etc., it is imperative that the use of correction factors for differences in quality (moisture or superheat) when the steam is near the saturation point should not be based on data that do not apply to the engine and the condition of the test.

If the tests are in connection with contract guarantees, all parties concerned should agree on the corrections prior to the final tests. In all cases the report, text and tabulation or summary should plainly state (first) the actual test results and (second) the estimated corrected result and, so far as possible, the corrections should be applied to the final computed test results and not to any of the component measurements, such as the total weight of steam per hour, etc.

DATA AND RESULTS

25 The data and results of the tests should be reported in accordance with the form (Table 1) given herewith, adding lines for data not provided for or omitting those not required. Unless otherwise indicated, the items should be the averages of all observations.

TABLE 1 DATA AND RESULTS OF RECIPROCATING DISPLACEMENT STEAM-PUMP TEST

A.S.M.E. Code of 1922

GENERAL INFORMATION

(1) Date of test
(2) Location
(3) Owner
(4) Builder
(5) Test conducted by
(6) Object of test

DESCRIPTION, DIMENSIONS, ETC.

(7) Type of unit
(8) Number of steam cylinders
(9) Diameter of steam cylinders: hp.....in.; i.p.....in.; l.p.....in
(10) Stroke of steam end
(11) Number of plungers
(12) Single or double-acting
(13) Diameter of plungers.....in.
(14) Stroke of plungers.....in.

(15) Type of condenser
(16) Cooling surface in condenser ..... sq. ft.
(17) Type and size of condenser pumps
(18) Type and size of any exhaust or receiver feed-water heaters, steam reheaters, and jacket pumps or other auxiliaries a part of the unit
(19) Vertical distance of gage on discharge main above or below datum line of pump cylinders ..... ft.
(20) Vertical distance of gage on suction main below or above datum line of pump cylinders ..... ft.

TEST DATA AND RESULTS

(21) Duration of test ..... hr.

Average Pressures:

(22) Barometric pressure ..... in. of mercury ..... lb. per sq. in.
(*a*) Corresponding absolute pressure ..... lb. per sq. in.
(23) Pressure in steam pipe near throttle by gage ..... lb. per sq. in.
(24) Pressure in 1st receiver by gage ..... lb. per sq. in.
(25) Pressure in 2nd receiver by gage ..... lb. per sq. in.
(26) Vacuum in exhaust pipe near engine by gage ..... in. of mercury
(*a*) Corresponding absolute pressure ..... lb. per sq. in.
(27) Pressure in jackets and reheater by gage ..... lb. per sq. in.

Temperatures:

(28) Temperature of external air ..... deg. fahr.
(29) Temperature of engine room ..... deg. fahr.
(30) Temperature of steam near throttle, if superheated ..... deg. fahr.
(31) Temperature of saturated steam at throttle pressure ..... deg. fahr.
(32) Temperature of saturated steam corresponding to pressure in exhaust pipe engine ..... deg. fahr.
(33) Temperature of steam in exhaust pipe as observed ..... deg. fahr.
(34) Temperature of condensate leaving jackets and reheaters ..... deg. fahr.
(35) Temperature of condensate leaving feedwater heaters ..... deg. fahr.
(36) Temperature of condensate leaving surface condenser ..... deg. fahr.
(37) Temperature of water in discharge main of pump ..... deg. fahr.

Water Pressures and Head:

(38) Pressure shown by gage on discharge main ..... lb.
(39) Vacuum or pressure shown by gage on suction main ..... in. of mercury or lb.
(40) Discharge pressure referred to datum line ..... ft.
(41) Suction lift or suction pressure referred to datum line ..... ft.
(42) Head, expressed in feet ..... ft.
(43) Head, expressed in lb. ..... lb.

Quality of Steam near Throttle:

(44) Number of degrees of superheat, if any ..... deg. fahr.
(45) Percentage of moisture in steam ..... per cent

Total Steam Quantities:

(46) Total steam consumed by engine as measured ..... lb.
(47) Total dry and saturated steam or superheated steam consumed (Par. 12) ..... lb.
(48) Total condensate from surface condenser ..... lb.
(49) Total consumption of feedwater ..... lb.
(50) Total condensate from jackets and reheaters ..... lb.
(51) Correction factor conforming to conditions agreed upon (See Pars. 12 and 12a)
(52) Equivalent total steam consumed conforming to conditions agreed upon (Items 46 × Item 51) ..... lb.

Total Pump Quantities:

(53) Total quantity of water pumped, in gallons ..... gal.
(54) Total quantity of water pumped, in pounds ..... lb.
(55) Total plunger displacement in gallons ..... gal.

Hourly Steam Quantities:

(56) Steam consumed per hour, as measured (Item 46 ÷ Item 21) ..... lb.
(57) Dry and saturated steam consumed per hour (Item 47 ÷ Item 21) ..... lb.
(58) Equivalent steam consumed, conforming to conditions agreed upon (Item 52 ÷ Item 21) ..... lb.

Hourly Pump Quantities:

(59) Quantity of water pumped per hour ..... lb.
(60) Leakage of plunger and pump values per hr. ..... lb.
(61) Plunger displacement per hour ..... lb.
(62) "Slip," in percentage of plunger displacement (Item 61 — Item 59) ÷ (Item 59 × 100) ..... per cent

Heat Consumption:

(63) Total heat above water at 32 deg. fahr. per lb. of steam at throttle ..... B.t.u.
(*a*) Heat of liquid at temperature of steam at exhaust pressure ..... B.t.u.
(*b*) Heat supplied per pound of steam ..... B.t.u.
(64) Heat consumed per hour (See Par. 13) ..... B.t.u.
(65) Heat available for work per lb. of steam, from adiabatic expansion between initial conditions and final pressure according to Rankine cycle (See Par. 16) ..... B.t.u.

	1st Cyl.	2d Cyl.	3d Cyl.

Indicator Diagrams:

(66) Nominal cut-off ..... per cent
(67) Mean effective pressure, engine ..... lb. per sq. in.
(68) Mean effective pressure, pump ..... lb. per sq. in.
(69) Maximum pressure above atmosphere ..... lb. per sq. in.
(70) Absolute back pressure at lowest point ..... lb. per sq. in.

Speed:

(71) Total number of revolutions
(72) Total number of single strokes
(73) Average length of stroke, if direct-acting ..... ft.
(74) Revolutions per minute ..... r.p.m.
(75) Single strokes per minute ..... str.p.m.
(76) Piston and plunger speed ..... ft. per min.

Power:

(77) Indicated horsepower developed by whole engine ..... i.hp.
(78) 1st cylinder, crank end ..... i.hp.
head end ..... i.hp.
(79) 2d cylinder, crank end ..... i.hp.
head end ..... i.hp.
(80) 3d cylinder, crank end ..... i.hp.
head end ..... i.hp.
(81) Indicated horsepower developed by pumps ..... i.hp.
(82) Water horsepower (Item 59 × Item 42) ÷ 1,980,000 ..... hp.

Economy Results:

(83) Steam consumed per i.hp-hr. as measured (Item 56 ÷ Item 77) ..... lb.
(84) Dry saturated or superheated steam consumed per i.hp-hr. (Item 57 ÷ Item 77) ..... lb.
(85) Estimated steam consumed per i.hp-hr. conforming to conditions agreed upon (Item 58 ÷ Item 77) ..... lb.
(86) Heat consumed per i.hp-hr. (Item 64 ÷ Item 77) ..... B.t.u.
(87) Heat available according to Rankine cycle per i.hp-hr. (Item 65 × Item 66) ..... B.t.u.

Efficiency Results:

(88) Thermal efficiency referred to i.hp. (2545 ÷ Item 86) × 100 ..... per cent
(89) Engine efficiency (referred to Rankine cycle) based on i.hp. (2545 ÷ Item 87) × 100 ..... per cent
(90) Hydraulic efficiency of pumps (Item 81 × 100) ÷ Item 81 ..... per cent
(91) Mechanical efficiency of engine and pump cylinders (Item 81 × 100) ÷ Item 77 ..... per cent
(92) Combined mechanical efficiency of entire engine and pump (Item 82 × 100) ÷ Item 77 ..... per cent

Duty:

(93) Duty per 1000 lb. of net steam, as measured (Item 54 × Item 42 × 1000) ÷ (Item 46) ..... ft-lb.
(94) Duty per 1,000,000 B.t.u. (Item 54 × Item 42 × 1,000,000) ÷ Item 63 ..... ft-lb.

Specimen Indicator Diagrams:

(95) Specimen diagrams from each steam cylinder and each pump cylinder

REVISED ECONOMY AND DUTY AFTER APPLYING CORRECTION FACTORS FOR VARIATIONS FROM CONTRACT CONDITIONS

26 The revised economy and duty [items (83)–(87), (93) and (94), Table 1] obtained after applying the correction factors, as described in the text, for the variations of the test conditions from the contract conditions should be tabulated here. The correction factors shall be stated in percentages, and the basis and method of determining them described.

DUTY TRIALS AND TESTS OF RECIPROCATING DISPLACEMENT PUMPS DRIVEN BY PRIME MOVERS OTHER THAN RECIPROCATING STEAM ENGINES

27 The rules given previously, governing the pumps, all apply to reciprocating pumps regardless of the type of driving apparatus.

28 For rules governing the driving machine, see code which applies to such machine (as an oil engine, gas engine, water wheel, etc.)

29 In cases in which the pump is driven by an electric motor, the characteristics and efficiency of the motor and the power input to the motor should be obtained and used in accordance with the rules of the American Institute of Electrical Engineers.

30 The form of the tabulation of the test results will be dependent on the object of the test and will, in general, be a combination of the parts of Table 1 which refer to the pump and the form recommended in the code applying to the driving machine.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A.S.M.E.

Research Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulas or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Fire Prevention A3-22. Fire and Explosion Hazards of Petroleums and Petroleum Products. A report of an investigation on this subject made by Messrs. S. H. Katz and N. A. C. Smith for the Bureau of Mines was recently issued as Serial No. 2400.

The report discusses in order, Fire Hazards in Oil Refineries, Fire Hazards Associated with Petroleum Products, Flammability of Petroleum and its Products, Vapor Pressure and Volatility, Vapor Pressure, Volatility, Flash Point, Fire Points, Explosive Limits, and Ignition Temperatures. Address H. Foster Bain, Director of the Bureau of Mines, Department of the Interior, Washington, D. C.

Forest Products A2-22. Experimental Work on the Development of a Theory of the Protection of Wood by Preservatives. Practical methods of preserving wood against the attack of low forms of life require the injection of some material which inhibits the attacking organism. A working hypothesis states that wood preservative must possess sufficient solubility in water to produce a solution of lethal concentration.

Presented at the American Chemical Society Meeting held at Pittsburgh, Pa., September 4 to 9. Address Charles L. Parsons, Secretary of the American Chemical Society, 1709 G Street, N. W., Washington, D. C.

Fuels A13-22. Fusibility of Coal Ash. Data regarding the softening temperatures of coal ash from several hundred coals from the different fields of the country are contained in the Bureau of Mines Bulletin No. 209, Fusibility of Ash from Coals of the United States, by W. A. Selvig, assistant analytical chemist, and A. C. Fieldner, supervising chemist.

The Bureau of Mines has made a general survey of the "fusing" or "softening" temperatures of the ash from coals of the United States. This information, when used together with the large number of coal analyses published by the Bureau, will assist the consumer of coal in comparing different coals, and in selecting the coal best adapted for his purpose.

Coal ash is the incombustible residue remaining after the complete combustion of coal; it is derived from the inorganic mineral constituents of the coal. The ash-forming constituents are (1) inherent or intrinsic impurities that are present in an intimate mixture with the coal substance, and are derived either from the original material or from external sources such as sedimentation and precipitation while the coal-forming plant remains accumulated; (2) impurities, formed either during the laying down of the coal bed or subsequently, that occur in the form of partings, veins, and nodules of clay, shale, "slate," pyrite, and calcite; and (3) impurities that become intimately mixed with the coal in the process of mining, such as fragments of roof and floor. Coal ash is composed largely of compounds of silica, alumina, lime, and iron, with smaller quantities of magnesia, titanium, and alkali compounds. Bulletin 209 may be obtained by addressing the Bureau of Mines, Washington, D. C.

Fuel Utilization A1-22. Fusibility of Coal Ash. See *Fuels A13-22.*

Heat A4-22. Color Temperature of Artificial Light Sources. See *Illumination A1-22.*

Illumination A1-22. Color Temperature of Artificial Light Sources. Bureau of Standards Scientific Paper No. 443, dealing with the measurement of the color temperature of the more efficient artificial-light sources, describes a new method for measuring color temperatures between 3000 and 4000 deg. abs. cent. Data are presented on the color temperature of the gas-filled tungsten lamp and carbon arc. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price 5 cents.

Temperature Measurements A1-22. Color Temperature of Artificial Light Sources. See *Illumination A1-22.*

Water, Sewage and Sanitation A1-22. Plumbing Systems in Dwellings. A tentative report on residence plumbing has been prepared by the sub-committee on plumbing of the Department of Commerce's Building Code Committee. This report presents recommendations for design of plumbing systems in one and two-family dwellings, and outlines the principles which it is believed should govern the public control of such work through plumbing codes and inspection. These recommendations are based on extensive series of experiments with plumbing equipment conducted at the Bureau of Standards under the direction of the sub-committee; also on investigations of practice and opinion in all parts of the country. This report is being sent out in limited numbers for comment and criticism, and the revised report published later for distribution.

Detailed rules for plumbing practice are now being prepared, and will be given in a subsequent report. The experimental work is being continued and demonstration equipment, open to public inspection, will soon be installed. Address Dr. S. W. Stratton, Director of the Bureau of Standards, Washington, D. C.

B—Research in Progress

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation or conference, to prevent unnecessary duplication of work, and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Ceramics and Glass B1-22. Economies in Brick-Kiln Operation. Under the supervision of R. T. Stull, supervising ceramist, and in coöperation with the American Face Brick Association, the National Paving Brick Manufacturers' Association, the Common Brick Manufacturers' Association, and the Hollow Building Tile Association, investigations are being continued by the United States Bureau of Mines at various commercial plants on industrial kilns burning heavy clay products, with the object of reducing fuel consumption, shortening the time of burning, and at the same time improving the quality of the product. In several cases results have shown the possibility of saving one-third of the fuel, and cutting down the burning time of the kiln by one-third, with a resulting saving in cost.

Some of the problems attacked by Mr. Stull are: cause and prevention of red core in brick; cause and effect of so-called "blue-smoke;" removal of sulphur fumes from kiln gases in order that they may be used in dryers; cause of slabbing or popping in clays high in siderite; cause of kiln glazing on shale brick (pavers) when certain coals are used; relation between porosity and rattler tests and effect of lamination of both; why some clays swell long before zero porosity is obtained; and cause of bloating of enamel ware. Considerable light has been thrown on the first four problems by work in connection with the oxidation of the incidental minerals found in clays.

Address H. Foster Bain, Director, Bureau of Mines, Washington, D. C.

Clay Products B1-22. Economies in Brick-Kiln Operation. See *Ceramics and Glass B1-22.*

Corrosion B6-22. Corrosion of Chromium Steels. By means of apparatus designed at the Bureau of Standards and which is now being tried out, it will be possible to regulate the corrosion tests which are being conducted on various metals more closely than is possible by simple immersion in acids, which is the usual method employed in a test of this kind. The apparatus is designed to raise and lower the specimens so that they will be subjected to alternate attacks of the acid or other corroding liquid and the oxidizing action of the atmosphere.

Corrosion B7-22. Experiments on Soil and Stray-Current Corrosion. See *Electrolysis B2-22.*

Electrolysis B2-22. Experiments on Soil and Stray-Current Corrosion. During the first half of the month the work of burying specimens of pipe in connection with the Bureau of Standards' soil-corrosion investigation was completed in the territory west of the Mississippi River, and definite arrangements have been made for burying the last group of pipes in the states bordering the Great Lakes. Attention has been directed to starting chemical investigations that have a bearing on the soil-corrosion research, on the study of the effect of lime on both soil corrosion and stray-current electrolysis, on the possibilities of cathodic protection against both stray-current electrolysis and soil corrosion.

Investigations have also been started in an attempt to throw light on the relation between the corrosion of iron and the physical structure of the metal.

Ferrous Alloys B1-22. Molybdenum Steel. The work on molybdenum as an alloying element in steel, conducted at the Ithaca, N. Y., field office of the United States Bureau of Mines, in coöperation with the Vanadium Corporation of America, will be continued in the present fiscal year as a Bureau of Mines problem. The object of this work is to add to the technical information on the value of molybdenum. One of the few elements entering into true alloy steels of which the United States possesses an abundance of high-grade ore, readily mined and handled. Though there are limitations to its use, it is plainly of great value in steel that is to be heat-treated to produce superior qualities.

Molybdenum is slowly taking rank along with nickel, chromium, and vanadium as alloying elements for high-grade steel.

Besides the more common physical tests, single-blow impact and repeated-impact tests have been made by the Bureau of Mines on the molybdenum and on comparison alloy steels in coöperation with the Wyman-Gordon Company.

Chief attention has been given to endurance tests. This work has been expedited by conclusions drawn from the recently reported work on endurance testing at the University of Illinois and at the Naval Experiment Station. The making of the steels and the heat treatment and preparation of test bars have been completed. Actual endurance testing remains to be done before complete conclusions can be drawn.

Further study is also to be made on the relationship of the "rise of temperature" method of endurance testing, and the regular method of actually testing the steels to destruction by long-time tests. Address H. Foster Bain, Director, Bureau of Mines, Washington, D. C.

Fuels B3-22. CARBONIZED LIGNITE FUEL. In the course of the lignite investigations being conducted by W. W. Odell, fuel engineer, of the Bureau of Mines, in coöperation with the University of North Dakota, two carloads of lignite were recently carbonized at the rate of 10 tons per day. A satisfactory residue was obtained at an approximate cost of $5.50 per ton, as against a cost of approximately $6.25 a ton for the residue produced in the oven used during the experiments conducted during the summer of 1921.

Address H. Foster Bain, Director of the Bureau of Mines, Washington, D. C.

Fuels B4-22. SCREEN SIZING OF COAL AND MINERALS. See *Mining, General B1-22.*

Iron and Steel B5-22. MOLYBDENUM STEEL. See *Ferrous Alloys B1-22.*

Iron and Steel B6-22. USE OF OXYGEN IN METALLURGICAL OPERATIONS. Use of oxygen in connection with the enrichment of the blast in the blast furnace and in practically all phases of pyrometallurgical work will increase, according to Dr. F. G. Cottrell, the efficiency of metallurgical operation with a resultant production of metals at lower cost and possibly the use of lower-grade ores.

The Bureau of Mines now has outlined plans for two studies which will be carried on simultaneously. The first will cover the present-day processes for the production of oxygen, in order to determine the feasibility of attempting to produce oxygen, or oxygenated air, in such amounts and at such a cost as to permit of its use in metallurgical operations. The second study will be devoted to the feasibility of using oxygen, or oxygenated air, in metallurgical operations.

Iron and Steel B7-22. SYNTHETIC CAST IRON. As is well known, pig iron is not produced on the Pacific Coast at the present time in sufficient quantities to meet the demand for iron of such grades as are required for foundry purposes. Foundry iron is costly, due to high freight rates on eastern iron that is brought in and to the high cost of coke suitable for use in the cupola. On the other hand, considerable steel scrap is to be had, and attention has been recently given by the members of the Electrometallurgical Section of the Northwest Station of the Bureau of Mines at Seattle to the problem of producing cast iron by melting scrap steel in the electric furnace. These conditions were established by numerous experiments conducted in a laboratory furnace holding 300 lb. of metal.

Address H. Foster Bain, Director of the Bureau of Mines, Washington, D. C.

Iron and Steel B8-22. EFFECT OF MANGANESE ON THE STRUCTURE OF STEEL. The effect of manganese on the structure of iron-carbon alloys in the annealed and the normalized conditions has been determined. This study forms part of the general investigation of iron alloys which is now in progress, and the results will be published as soon as possible by the Bureau of Standards.

Metal Manufactures, Miscellaneous B2-22. CAUSE OF SPECKING OF GROUND COAT ENAMELS. Some preliminary tests have been conducted by the Bureau of Standards in a study of the causes of specking of ground-coat enamels. This specking appears as spots of oxide and slag in the enamel coating, a condition which appears to be due to excessive local rusting of the steel previous to the firing of the enamel.

Preliminary tests have been made on steel cups furnished by a manufacturer of such articles and coated with regular stock enamels. The results of the test indicate that the rusting and subsequent specking are due to an excess of acid or salts in the enamel. The defect has been remedied by the addition of sufficient sodium hydroxide to the enamel previous to the dipping operation. Since this defect is a serious one in the production of white enamel ware, it will probably be advisable to continue this investigation in order to go into the subject more thoroughly.

Metallurgy and Metallography B2-22. USE OF OXYGEN IN METALLURGICAL OPERATIONS. See *Iron and Steel B6-22.*

Mining, General B1-22. SCREEN SIZING OF COAL AND MINERALS. A study is being made by the Bureau of Mines at Urbana, Ill., of the equipment and methods used in screen sizing of coal and coke, metalliferous ores, stone gravel, and various mineral products.

Non-Ferrous Metals B3-22. HEAT TREATMENT OF NON-FERROUS ALLOYS. At the Pittsburgh, Pa., experiment station of the Bureau of Mines heat-treatment experiments, including quenching and annealing, have been conducted on a number of cast non-ferrous alloys including the following: 88 : 10 : 2 Cu-Sn-Zn; 85 : 5 : 5 Cu-Sn-Zn-Pb; 85 : 4 : 5 : 6 Cu-Sn-Zn-Pb; 90 : 10 Cu-Sn; 90 : 6 : 3 : 1 Cu-Sn-Zn-Pb; 85 : 15 Cu-Sn; 86 : 4 : 6 : 3 : 1 Cu-Ni-Sn-Zn-Pb; and 89.9 : 10 : 0.1 Cu-Sn-P. The results are being summarized.

Address Prof. M. D. Hersey, Bureau of Mines, 4800 Forbes Street, Pittsburgh, Pa.

Ventilation B2-22. PHYSIOLOGICAL EFFECTS OF HIGH TEMPERATURES AND HUMIDITIES. The Bureau of Mines, in coöperation with the United States Public Health Service and the Society of Heating and Ventilating Engineers, is engaged in a study of the relative importance and correct correlation of the many individual factors concerned in the problem of the physiological effects of different conditions of temperature, humidity, and air motion.

INFLUENCE OF DESIGN ON COST OF OPERATING AIRPLANES

(Continued from page 825)

COMPARISON WITH RAILROAD COST

A detailed and comprehensive comparison of airplane cost with railroad rates is not within the scope of this paper. However, one example is cited to emphasize the importance of the foregoing figures and to correct the impression that air transport is enormously expensive. The distance from New York to Chicago, as previously stated, is 908 miles on the Pennsylvania Railroad or about 700 miles in a straight line, a flying distance, say, of from 750 to 800 miles. *Were it possible to load the airplane fully on each trip*, the operating cost would be 6.5 cents per passenger-mile or $48.75 to $52 per passenger. This compares with the railroad rate of $51.30, including fare, excess fare, and pullman. Allowing for the trip to and from the fields, as well as an intermediate stop, the time by air would average about 9 hours as against 20 hours by the Pennsylvania Railroad's "Broadway Limited." The only reason why we cannot carry passengers at such rates today is that it costs too much to get the business.

CONCLUSIONS

The following general conclusions may be drawn from the data considered:

Duration. That designed duration should not exceed the minimum necessary to complete scheduled trips safely in a head wind and that, for the type considered, it should not in any case exceed four hours.

Factor of Safety. That the factor of safety should be kept to the minimum consistent with the conditions and that it should in no case exceed six.

High Speed. That high speeds beyond those accompanying the necessary reserve horsepower are undesirable and, for the type considered, the high speed should not exceed 105 to 110 m.p.h. at 5000 ft.

Climbing Speed. That climbing speed should be only sufficient to provide a reasonable margin of safety for emergencies, and an initial rate of climb of 400 to 500 ft. (from the altitude of the operating field) in the first minute is proposed as a tentative standard.

Reserve Horsepower. That reserve horsepower should be kept down to that necessary to provide the required climbing speed.

Flying on One out of Two Engines. That flying on one out of two engines is utterly impracticable, because of prohibitive cost.

Flying on Two out of Three Engines. That the requirement of ability to fly on two out of three engines is reasonable and practicable.

Safety Requirements. That initial rate of climb instead of reserve horsepower or speed range should be the measure of safe performance.

Size. That the moderate-sized machine is the most efficient at present, and for the type considered this size is about 500 to 600 sq. ft. in area.

Operating Cost. That aircraft designed for commercial purposes and fully loaded can be operated conservatively at a total cost of 0.030 to 0.032 cent per pound-mile or about 6.5 cents per passenger-mile, not including the cost of obtaining the business, and that this cost cannot be even approached by machines not suited to the purpose.

Second Revision of A.S.M.E. Boiler Code, 1922

A HEARING is held by the Boiler Code Committee at least once in four years, at which all interested parties may be heard, in order that such revisions may be made as are found to be desirable, as the state of the art advances. The year 1922 becomes the period of the second revision, the first revised edition of the Boiler Code having been issued in 1918. The Boiler Code Committee plans to hold a Public Hearing in connection with the next Annual Meeting of the Society in December, 1922, to which the membership of the Society and everyone interested in the steam-boiler industry will be invited and where they may present their views.

In the course of the Boiler Code Committee's work during the past four years, many suggestions have been received for revisions of the Power Boiler Section of the Code, as a result of the interpretations issued and also of the formulation of the Locomotive Boiler and Miniature Boiler Codes. In order that due consideration might be accorded to these recommendations, the Committee began in the early part of 1921 to devote an extra day at each of its monthly meetings to the consideration of the proposed revisions. As a result of this many of the recommendations have been accepted and revisions of the paragraphs formulated.

The revisions which have met the approval of the Boiler Code Committee are here published. It is the request of the Committee that these revisions be fully and freely discussed so that it may be possible for anyone to suggest changes before the rules are brought to final form and presented to the Council for approval. Discussions should be mailed to C. W. Obert, Secretary to the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Boiler Code Committee for consideration.

The revisions here published are limited to the paragraphs appearing in the 1918 Edition of the A.S.M.E. Boiler Code, and the paragraph numbers refer to the paragraphs of similar number in that edition. For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PREAMBLE:—ADD THE FOLLOWING TO THE PREAMBLE:

THE COMMITTEE DOES NOT EXPRESS OPINIONS ON TYPES OF BOILERS OR APPARATUS, NOR APPROVE OR DISAPPROVE OF ANY GENERAL DESIGN OR ESTABLISH WORKING PRESSURES THAT MAY BE CARRIED FOR SPECIFIC DESIGNS. FOR EXAMPLE, SHOULD A BOILER BE SUBMITTED BY A TRADE NAME OR THAT OF THE MANUFACTURER FOR APPROVAL OF THE BOILER CODE COMMITTEE, THE BOILER CODE COMMITTEE WOULD NOT EXPRESS ITS APPROVAL OR DISAPPROVAL. THE BOILER CODE COMMITTEE WOULD, HOWEVER, STAND READY TO INTERPRET ANY ONE OF THE RULES OF THE CODE AS APPLIED TO THE BOILER, BUT IT WOULD NOT SET THE PRESSURE THAT COULD BE CARRIED NOR PASS ANY OPINION IN REGARD TO THE MERITS OF A BOILER OR APPARATUS.

PAR. 1 REVISED:

1 Specifications are given in these Rules for the important materials used in the construction of boilers and where given, the materials shall conform thereto. IF, IN THE DEVELOPMENT OF THE ART OF BOILER CONSTRUCTION, OTHER MATERIALS THAN THOSE HEREIN DESCRIBED BECOME AVAILABLE, SPECIFICATIONS FOR THE SAME MAY BE SUBMITTED FOR CONSIDERATION AND APPROVAL.

PAR. 11 REVISED:

11 Pressure parts of superheaters, separately fired or attached to stationary boilers, unless of the locomotive type, shall be of wrought steel, PUDDLED OR KNOBBLED CHARCOAL WROUGHT IRON, or cast steel of Class B grade, as designated in the Specifications for Steel Castings.

PAR. 19 ADD THE FOLLOWING TO THIS PARAGRAPH:

FOR PLATES OVER 1 IN. IN THICKNESS, WHERE THE SHEET IS HEAVIER THAN ORDINARILY REQUIRED IN ORDER TO AFFORD GREATER STRENGTH OF TUBE-HOLE LIGAMENTS, THE BUTT STRAPS MAY BE PROPORTIONED IN ACCORDANCE WITH THE *required* THICKNESS, BUT IN NO CASE MAY THEY BE LESS THAN ONE-HALF THE PLATE THICKNESS.

PAR. 21 REVISED:

21 *Tubes for Water-Tube Boilers.* The maximum allowable working pressures for tubes used in water-tube boilers shall be for the various diameters and gages measured by Birmingham wire gage, as given in Table 2. REDRAWN PIPE NOT TO EXCEED 1 1/2 IN. STANDARD PIPE SIZE WHICH MEETS THE PIPE SPECIFICATION, MAY BE USED FOR WATER-TUBE BOILERS FOR A WORKING PRESSURE NOT TO EXCEED 200 LB. PER SQ. IN., WHEN SCREWED IN THE SHEET, PROVIDED THE WALL THICKNESS IS AT LEAST 50 PER CENT GREATER THAN THE WALL THICKNESS REQUIRED BY TABLE 2.

PAR. 182 ADD THE FOLLOWING TO REVISED FORM AS PUBLISHED IN THE JULY ISSUE OF MECHANICAL ENGINEERING:

THE BACK PITCH OF TUBE HOLES OR RIVETS SHALL BE MEASURED EITHER ON THE FLAT PLATE BEFORE ROLLING, OR ON THE MEDIAN LINE AFTER ROLLING.

PAR. 185 REVISED:

185 When shell plates exceed 3/16 in. in thickness in horizontal-return-tubular boilers, the portion of the SHELL plate [s] forming the laps of the circumferential joints, where exposed to the fire or products of combustion, shall be planed or milled down as shown in Fig. 8, to A THICKNESS OF NOT OVER 1/2 in. [in thickness], provided the requirement in Par. 184 is complied with.

PAR. 187 CHANGE PARS. 187 AND 188 TO PARS. 188*a* AND 188*b* AND INSERT A NEW PAR. 187 AS FOLLOWS:

187 *Seamless Construction.* DRUMS, SHELLS OR DOMES MAY BE OF SEAMLESS DRAWN CONSTRUCTION WITH OR WITHOUT INTEGRAL HEADS PROVIDED THE MATERIAL FROM WHICH THEY ARE FORMED CONFORMS TO THE REQUIREMENTS OF ANY ONE OF THE SPECIFICATIONS IN THE CODE FOR SHELL MATERIAL.

PAR. 193 CHANGE PAR. 193 TO PAR. 192*d* AND INSERT NEW PAR. 193 AS FOLLOWS:

193 IN APPLYING REINFORCING PLATES TO THE DRUMS OF WATER-TUBE BOILERS TO STRENGTHEN THE SHELL WHERE THE TUBES ENTER, THEY SHALL BE RIVETED TO THE SHELL, AND THE TUBES SHALL BE EXPANDED INTO THE INNER AND OUTER PLATES SO THAT THE RIVETS AND TUBES WILL HOLD THE PLATES TOGETHER IN ACCORDANCE WITH THE RULES FOR STAYED SURFACES.

THE SPACING OF THE RIVETS WITH RESPECT TO THE TUBES SHALL CONFORM TO PAR. 199 FOR STAYED SURFACES, USING A VALUE OF 135 FOR C, AND SHALL BE BASED ON A UNIT PRESSURE EQUAL TO THE PRESSURE THAT CAN BE CARRIED BY THE INNER PLATE WITH A FACTOR OF SAFETY OF 5.

(NOTE: WHERE A REINFORCING PLATE IS INSIDE THE STEAM DRUM IT IS THE INNER PLATE; WHERE IT IS OUTSIDE AND THERE IS NO INNER REINFORCING PLATE, THE UNREINFORCED SHELL OF THE DRUM IS THE INNER PLATE.)

THE TENSION IN RIVETS AND TUBES SHALL CONFORM TO PARS. 220 AND 232.

THE COMBINED DRUM SHELL AND REINFORCING PLATE OR PLATES SHALL HAVE A FACTOR OF SAFETY OF NOT LESS THAN 5 IN THE LIGAMENTS, WHEN CALCULATED IN ACCORDANCE WITH PAR. 192, ALSO IN RIVET CONNECTIONS. WHEN REINFORCING PLATES OR BUTT STRAPS ARE EXPOSED TO FLAME OR GAS OF THE EQUIVALENT TEMPERATURE, THE JOINTS SHALL BE PROTECTED THEREFROM.

PAR. 195 REVISED:

195 [Convex Heads.] The thickness required in an unstayed dished head with the pressure on the concave side, when it is a segment of a sphere, shall be calculated by the following formula:

$$t = \frac{5.5 \times P \times L}{2 \times TS} + 1/8$$

where

t = thickness of plate, in.
P = maximum allowable working pressure, lb. per sq. in.
TS = tensile strength, lb. per sq. in.

NOTE:—Matter in caps—added matter; matter in brackets—to be deleted.

L = radius to which the head is dished, in.

Where two radii are used the longer shall be taken as the value of L in the formula.

Where the radius is less than 80 per cent of the diameter of the shell or drum to which the head is attached the thickness shall be at least that found by the formula by making L equal to 80 per cent of the diameter of the shell or drum.

[Concave Heads.] Dished heads with the pressure on the convex side shall have a maximum allowable working pressure equal to 60 per cent of that for heads of the same dimensions with the pressure on the concave side.

When a dished head has a manhole opening, the thickness as found by these Rules shall be increased by not less than $^1/_8$ in. over that called for by the formula. Where a dished head has a flanged opening supported by an attached flue, the increase of $^1/_8$ in. in thickness is not required. IF MORE THAN ONE MANHOLE OPENING IS INSERTED, THE MINIMUM DISTANCE BETWEEN THE OPENINGS SHALL BE NOT LESS THAN ONE-FOURTH OF THE OUTSIDE DIAMETER OF THE HEAD.

PAR. 199 REVISED:

199 The maximum allowable working pressure for various thicknesses of braced and stayed flat plates and those which by these Rules require staying as flat surfaces with braces or staybolts of uniform diameter symmetrically spaced, shall be calculated by the formula:

$$P = C \times \frac{T^2}{p^2}$$

where

P = maximum allowable working pressure, lb. per sq. in.

T = thickness of plate in *sixteenths* of an inch

p = maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical or inclined, in.

C = 112 for stays screwed through plates not over $^7/_{16}$ in. thick with ends riveted over

C = 120 for stays screwed through plates over $^7/_{16}$ in. thick with ends riveted over

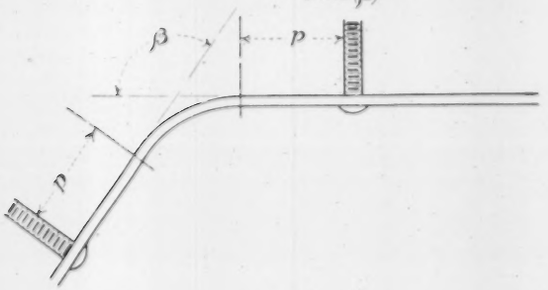
C = 135 for stays screwed through plates and fitted with single nuts outside of plate OR WITH INSIDE AND OUTSIDE NUTS OMITTING WASHERS

C = 150 for stays with heads not less than 1.3 times the diameter of the stays, screwed through plates or made a taper fit and having the heads formed on the stays before installing them and not riveted over, said heads being made to have a true bearing on the plate

C = 175 for stays fitted with inside and outside nuts and outside STEEL washers where the diameter of washers is not less than 0.4 p and thickness not less than T.

FOR STAYS AT THE UPPER CORNERS OF FIREBOXES THE PITCH FROM THE STAYBOLT NEXT TO THE CORNER TO THE POINT OF TANGENCY OF THE CORNER CURVE SHOULD BE,

$$P = 90 \sqrt{\frac{C \frac{T^2}{P}}{\text{Angularity of Tangent-Lines } (\beta)}}$$



If a flat boiler plate not less than $^3/_8$ in. thick is strengthened with a doubling plate covering the full area of the stayed surface and securely riveted thereto and having a thickness of not less than $^3/_4$ T, then the value of T in the formula shall be three-quarters of the combined thickness of the boiler plate and doubling plate but not more than one and one-half times the thickness of the boiler plate, and the value of C given above may also be increased 15 per cent.

When two sheets are connected by stays and but one of these sheets requires staying, the value of C is governed by the thickness of the sheet requiring staying.

Acceptable proportions for the ends of through stays with washers are indicated in Fig. 14.

FIG. 14 REVISE SIDE EXPLANATION TO READ:

Not less than 2$^1/_2$ Diameters of Bolt AS MEASURED ON THE OUTSIDE OF THE THREADED PORTION but must be 0.4 Pitch of Stays if C = 175.

PAR. 196 REVISED:

196 When dished heads are of a less thickness than called for by Par. 195, they shall be stayed as flat surfaces, no allowance being made in such staying for the holding power due to the spherical form. IF A DISHED HEAD IS FORMED WITH A FLATTENED SPOT OR SURFACE FOR THE ATTACHMENT OF A CONNECTION OR FLANGE, THE DIAMETER OF THE FLAT SPOT SHOULD NOT EXCEED THE VALUE OF p AS GIVEN IN THE FORMULA IN PAR. 199 OR IN TABLE 4, FOR THE PRESSURE AND THICKNESS OF HEAD INVOLVED.

PAR. 200 REVISED:

200 *Staybolts.* The ends of [screwed] staybolts OR STAYS SCREWED THROUGH PLATES, shall be riveted over or upset by equivalent process OR FITTED WITH NUTS. The outside ends of solid staybolts, 8 in. and less in length, shall be drilled with a hole at least $^3/_{16}$ in. diameter to a depth extending at least $^1/_2$ in. beyond the inside of the plates, or hollow staybolts may be used. On boilers having a grate area not exceeding 15 sq. ft., or the equivalent in gas- or oil-fired boilers, the drilling of staybolts is optional. Solid staybolts over 8 in. long, and flexible staybolts of either the jointed or ball-and-socket type, need not be drilled. Staybolts used in waterlegs of water-tube boilers shall be hollow or drilled at both ends, irrespective of their length. ALL STAYBOLTS NOT NORMAL TO THE STAYED SURFACE SHALL HAVE THREE ENGAGING THREADS OF WHICH ONE SHALL BE A FULL THREAD.

PAR. 208 REVISED:

208 The diameter of a screw stay shall be taken at the bottom of the thread OR WHEREVER IT IS OF [provided this is] the least diameter.

PAR. 212*a* REVISED:

212*a* The maximum allowable working pressure for any curved stayed surface subject to internal pressure shall be obtained by the two following methods, and the minimum value obtained shall be used:

First, the maximum allowable working pressure shall be computed without allowing for the holding power of the stays, due allowance being made for the weakening effect of the holes for the stays OR RIVETED LONGITUDINAL JOINT OR OTHER CONSTRUCTION EXCEPT HAND-HOLES. To this pressure there shall be added the pressure secured by the formula for braced and stayed surfaces given in Par. 199, using 70 for the value of C.

Second, the maximum allowable working pressure shall be computed without allowing for the holding power of the stays, due allowance being made for the weakening effect of the holes for the stays OR RIVETED LONGITUDINAL JOINT OR OTHER CONSTRUCTION EXCEPT HANDHOLES. To this pressure there shall be added the pressure corresponding to the strength of the stays for the stresses given in Table 5, each stay being assumed to resist the steam pressure acting on the full area of the external surface supported by the stay.

PAR. 212*b* ADD THE FOLLOWING TO THIS PARAGRAPH:

THE ABOVE FORMULA APPLIES TO THE LONGITUDINAL CENTER SECTION OF THE WRAPPER SHEET, AND IN CASES WHERE E IS REDUCED AT ANOTHER SECTION, THE MAXIMUM ALLOWABLE WORKING PRESSURE BASED ON THE STRENGTH AT THAT SECTION, MAY BE INCREASED IN THE PROPORTION THAT THE DISTANCE FROM THE WRAPPER SHEET TO THE TOP OF THE CROWN SHEET AT THE CENTER, BEARS TO THE DISTANCE, MEASURED ON A RADIAL LINE THROUGH THE OTHER SECTION, FROM THE WRAPPER SHEET TO A LINE TANGENT

TO THE CROWN SHEET AND AT RIGHT ANGLES TO THE RADIAL LINE. (SEE FIG. 14½.)

PAR. 216 REVISED:

216 Stays shall be used in the tube sheets of a fire-tube boiler if the distance between the edges of the tube holes exceeds the maximum pitch of staybolts for the corresponding plate thickness and pressure given in Table 4. That part of the tube sheet which comes between the tubes and the shell need not be stayed, if the GREATEST distance [to the nearest tangent common to two tube holes when] measured ALONG A RADIAL LINE FROM THE INNER SURFACE OF THE SHELL TO THE CENTER POINT OF THE TANGENT COMMON TO ANY TWO TUBE HOLES ON THE SHELL SIDE OF SUCH [on any radius of the tube sheet that intersects the tangent between the] holes does not exceed 1.25 TIMES THE [this] maximum pitch OF STAYBOLTS FOR THE CORRESPONDING PLATE THICKNESS AND PRESSURE GIVEN IN TABLE 4 [by more than 3 in.]. The tube holes to which a common tangent may be drawn in applying this rule shall not be at a greater distance from edge to edge than the maximum pitch referred to.

PAR. 218 REVISED:

218 When STAYS ARE REQUIRED the portion of the heads below the tubes in a horizontal-return-tubular boiler SHALL BE SUPPORTED BY THROUGH STAYS WITH NUTS AT THE FRONT HEAD. WHERE a manhole opening is provided [with] the flange of which is formed from the solid plate and turned inward to a depth of not less than three times the required thickness of the head, measured from the outside, the area to be stayed as indicated in Fig. 16, may be reduced by 100 sq. in. [The surface around the manhole shall be supported by through stays with nuts inside and outside at the front head.]

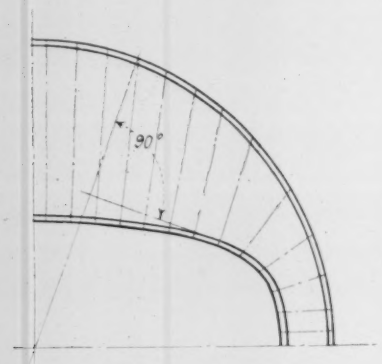


FIG. 14½ STAYING FOR WRAPPER SHEET OF LOCOMOTIVE BOILER

The distance in the clear between the bodies of the braces, or of the inside braces where more than two are used, shall not be less than 10 in. at any point.

TABLE 5 PLACE AN ASTERISK AFTER THE WORD "DIAMETER" EACH TIME IT APPEARS IN THIS TABLE, AND INSERT THE FOLLOWING NOTE AT BOTTOM OF TABLE:

* DIAMETERS TAKEN AT BODY OF STAY.

PAR. 230 ADD THE FOLLOWING TO THIS PARAGRAPH:

IN A FORM OF REINFORCEMENT FOR CROWN SHEETS WHERE THE TOP SHEET OF THE FIREBOX IS A PART OF A TRUE CIRCLE NOT EXCEEDING 120 DEG. IN ARC, AND IS BRACED WITH ARCH BARS EXTENDING OVER THE TOP AND DOWN BELOW THE TOP ROW OF STAYBOLTS AT THE SIDES, THESE ARCH BARS BEING RIVETED TO THE WATER SIDE OF THE CROWN SHEET THROUGH THIMBLES, THE MAXIMUM ALLOWABLE WORKING PRESSURE SHOULD BE DETERMINED BY ADDING TO THE MAXIMUM ALLOWABLE WORKING PRESSURE FOR A PLAIN CIRCULAR FURNACE OF THE SAME THICKNESS, DIAMETER AND LENGTH BY THE FORMULA IN PAR. 239, THE PRESSURE P_1 DETERMINED FROM THE FOLLOWING FORMULA, WHICH IS A MODIFICATION OF THAT IN PAR. 241, SECTION *a*

$$P_1 = 10{,}000{,}000\,\frac{b \times d^3}{p \times D^3}$$

WHERE

b = net width of crown bar, in.

d = depth of crown bar, in.

p = longitudinal pitch of crown bar, in.

D = outside diameter of furnace, in.

PROVIDED THAT THE MAXIMUM ALLOWABLE WORKING PRESSURE MUST NOT EXCEED THAT DETERMINED BY THE FORMULA FOR FURNACES OF THE ADAMSON TYPE, IN PAR. 242 WHEN L IS MADE EQUAL TO p, AND ALSO PROVIDED THAT THE DIAMETER OF THE HOLES FOR THE STAYBOLTS IN THE CROWN BARS DOES NOT EXCEED ⅓ b, AND THE CROSS-SECTIONAL AREA OF THE CROWN BARS IS NOT LESS THAN 4 SQ. IN., PAR. 199 WOULD GOVERN THE SPACING OF THE STAYBOLTS, RIVETS OR BOLTS ATTACHING THE SHEET TO THE BARS, AND PAR. 212*b* THE SIZE OF THE STAYBOLTS, RIVETS OR BOLTS.

PAR. 231 REVISED:

231 *Maximum Allowable Working Pressure on Truncated Cones.* *a* Upper combustion chambers of vertical submerged tubular boilers made in the shape of a frustum of a cone when not over 38 in. diameter at the large end, may be used without stays if computed by the rule for plain cylindrical furnaces (Par. 239) making D in the formula equal to the diameter at the large end; provided that the longitudinal joint conforms to the requirements of Par. 239.

b When over 38 in. in diameter at the large end, that portion which is over 30 in. in diameter shall be [fully] supported by staybolts or gussets. IF SUPPORTED BY STAYBOLTS PAR. 212D SHALL APPLY. IF SUPPORTED BY GUSSETS THE SPACING OF THE RIVETS ATTACHING THE GUSSETS TO THE COMBUSTION CHAMBER SHALL NOT EXCEED THE STAYBOLT SPACING GIVEN BY PAR. 212D. [to conform to the provisions for staying flat surfaces. In this case.] The top row of staybolts shall be at a point where the cone top is 30 in. or less in diameter.

In calculating the pressure permissible on the unstayed portion of the cone, the vertical distance between the horizontal planes passing through the centers of the rivets at the cone top, and through the center of the top row of staybolts shall be used as L in Par. 239, and D in that paragraph shall be the inside diameter at the center of the top row of staybolts.

PAR. 239 REVISED:

239 *PLAIN CIRCULAR FURNACES.* THE FOLLOWING RULES APPLY IN GENERAL TO UNSTAYED CIRCULAR FURNACES:

a-1 THE LONGITUDINAL JOINT MAY BE RIVETED OR LAP WELDED BY THE FORGING PROCESS, OR THE FURNACE MAY BE OF SEAMLESS CONSTRUCTION

a-2 THE LONGITUDINAL JOINT IF RIVETED SHALL HAVE AN EFFICIENCY GREATER THAN

$$\frac{P \times D}{1250 \times T}$$

a-3 THE WALLS SHALL NOT BE LESS THAN 5/16 IN. THICK

a-4 BUTT STRAP SEAMS SHALL BE USED ONLY WHERE THEY ARE PROTECTED FROM CONTACT WITH THE FIRE

a-5 THE FURNACE MAY BE OF ANY LENGTH OR HEIGHT

PAR. 240 OMIT THIS PARAGRAPH AND REPLACE BY THE FOLLOWING:

240 THE FOLLOWING RULES APPLY SPECIFICALLY TO UNSTAYED CIRCULAR FURNACES 12 IN. IN DIAMETER AND OVER:

A 12 IN. TO 18 IN. OUTSIDE DIAMETER, INCLUSIVE.

b-1 A RIVETED LONGITUDINAL JOINT MAY BE OF THE LAP TYPE

b-2 THE MAXIMUM ALLOWABLE WORKING PRESSURE FOR FURNACES NOT MORE THAN FOUR AND A HALF DIAMETERS IN LENGTH OR HEIGHT SHALL BE DETERMINED BY FORMULAE *a* AND *b* AS FOLLOWS:

a WHERE THE LENGTH DOES NOT EXCEED 120 TIMES THE THICKNESS OF THE PLATE

$$P = \frac{51.5}{D}\,[(18.75 \times T) - (1.03 \times L)]$$

b WHERE THE LENGTH EXCEEDS 120 TIMES THE THICKNESS OF THE PLATE

$$P = \frac{4250 \times T^2}{L \times D}$$

WHERE

P = MAXIMUM ALLOWABLE WORKING PRESSURE, LB. PER SQ. IN.

D = OUTSIDE DIAMETER OF FURNACE, IN.

L = TOTAL LENGTH OF FURNACE BETWEEN CENTERS OF HEAD RIVET SEAMS (NOT LENGTH OF A SECTION), IN.

T = THICKNESS OF FURNACE WALLS, IN SIXTEENTHS OF AN INCH

b-3 THE MAXIMUM ALLOWABLE WORKING PRESSURE FOR FURNACES OVER FOUR AND ONE-HALF DIAMETERS IN LENGTH OR HEIGHT SHALL BE DETERMINED IN ACCORDANCE WITH PAR. 241.

B OVER 18 IN. OUTSIDE DIAMETER TO AND INCLUDING 30 IN. INSIDE DIAMETER.

c-1 A RIVETED LONGITUDINAL JOINT MAY BE OF THE LAP TYPE

c-2 THE MAXIMUM ALLOWABLE WORKING PRESSURE SHALL BE DETERMINED BY FORMULAE a AND b IN A; IF OVER SIX DIAMETERS IN LENGTH OR HEIGHT, l, IN THE FORMULA SHALL BE TAKEN AS SIX TIMES THE DIAMETER.

C OVER 30 IN. INSIDE DIAMETER TO AND INCLUDING 36 IN. INSIDE DIAMETER.

d-1 A RIVETED LONGITUDINAL JOINT MAY BE OF THE LAP TYPE PROVIDED THE FURNACE DOES NOT EXCEED 36 IN. IN LENGTH OR HEIGHT

d-2 IF THE LENGTH OF A HORIZONTAL FURNACE EXCEEDS 36 IN. AND THE JOINT IS RIVETED, A BUTT AND SINGLE OR DOUBLE STRAP CONSTRUCTION SHALL BE USED AND SHALL BE LOCATED BELOW THE GRATE

d-3 THE MAXIMUM ALLOWABLE WORKING PRESSURE SHALL BE DETERMINED BY FORMULAE a AND b IN A; IF OVER SIX DIAMETERS IN LENGTH L IN THE FORMULA SHALL BE TAKEN SIX TIMES THE DIAMETER.

D OVER 36 IN. INSIDE DIAMETER TO AND INCLUDING 38 IN. OUTSIDE DIAMETER.

e-1 WHEN RIVETED THE LONGITUDINAL JOINT OF A HORIZONTAL FURNACE SHALL BE BUTT AND SINGLE OR DOUBLE STRAP CONSTRUCTION AND SHALL BE LOCATED BELOW THE GRATE

e-2 THE MAXIMUM ALLOWABLE WORKING PRESSURE SHALL BE DETERMINED BY FORMULAE a AND b IN A; IF OVER SIX DIAMETERS IN LENGTH L IN THE FORMULA SHALL BE TAKEN AS SIX TIMES THE DIAMETER.

PAR. 248 COMBINE THIS PARAGRAPH WITH PAR. 249 AND INSERT FOLLOWING NEW PARAGRAPH:

CUTTING OF PLATES

248 PLATES MAY BE CUT BY MACHINING, PUNCHING, SHEARING OR CUTTING BY THE ELECTRIC ARC OR GAS, PROVIDED ENOUGH METAL IS LEFT AT ANY UNFINISHED EDGES TO MEET THE REQUIREMENTS OF PARS. 249, 253, AND 257.

PAR. 250 REVISED:

250 A fire-tube boiler WITH TUBES UNDER 5 IN. DIAMETER shall have THE [both] ends of the tubes FIRMLY [substantially] rolled and beaded, or rolled and welded at the firebox or combustion-chamber end, AND ROLLED AND BEADED AT THE OTHER END. IN THE CASE OF TUBES UNDER 1¼ IN. DIAMETER, THE TUBES MAY BE EXPANDED BY THE PROSSER METHOD IN PLACE OF ROLLING. IN THE CASE OF TUBES 5 IN. IN DIAMETER AND OVER, THE TUBES SHALL BE SECURED BY RIVETING OR OTHER APPROVED METHOD AT BOTH ENDS. IF WELDED, THE WELDING SHALL BE AROUND THE EDGE OF THE BEAD OR IF THE TUBE IS NOT BEADED THE TUBE SHEET SHALL BE CHAMFERED OR RECESSED TO A DEPTH AT LEAST EQUAL TO THE THICKNESS OF THE TUBE. IN NO CASE SHALL THE TUBE END EXTEND MORE THAN ⅜ IN. BEYOND THE TUBE SHEET.

PAR. 251 REVISED:

251 The ends of all tubes, suspension tubes and nipples shall be flared not less than ⅛ in. over the diameter of the tube hole on all water-tube boilers and superheaters, or they may be flared not less than ⅛ in., rolled and beaded, or flared, rolled and welded. WHERE SPECIAL REDRAWN PIPE AS PROVIDED IN PAR. 21 IS USED FOR TUBES IN WATER-TUBE BOILERS, THE MINIMUM NUMBER OF THREADS SHALL CONFORM WITH THE VALUES GIVEN IN TABLE 8. THE CLOSED ENDS OF THE STUB TUBES SHALL BE WELDED BY THE FORGING PROCESS.

FIG. 20 CHANGE NOTE AT BOTTOM OF FIGURE TO READ:

Dimensions OF FINISHED HEADS may be larger or 1/10 smaller than those shown. Fillets under heads may be used but are not required.

CHANGE CAPTION TO READ: Acceptable Forms of FINISHED Rivet Heads.

PAR. 253 REVISED:

253 *Drilling of Holes.* ALL HOLES IN BRACES, LUGS AND SHEETS FOR RIVETS OR STAYBOLTS SHALL BE DRILLED, OR THEY MAY BE PUNCHED, AT LEAST ⅛ IN. LESS THAN FULL DIAMETER FOR MATERIAL NOT MORE THAN 5/16 IN. THICK, AND AT LEAST ¼ IN. LESS THAN FULL DIAMETER FOR THICKER MATERIAL, NOT MORE THAN ⅝ IN. THICK.

HOLES SHALL NOT BE PUNCHED IN MATERIAL MORE THAN ⅝ IN. THICK.

FOR FINISHING THE RIVET HOLES, THE PLATES, BUTT STRAPS, BRACES, HEADS AND LUGS SHALL BE FIRMLY BOLTED IN POSITION BY TACK BOLTS, FOR FINAL DRILLING OR REAMING TO FULL DIAMETER.

THE FINISHED HOLES MUST BE TRUE, CLEAN AND CONCENTRIC.

PAR. 255 REVISED:

255 *Rivets.* Rivets shall be of sufficient length to completely fill the rivet holes and form heads at least equal in strength to the bodies of the rivets. Forms of FINISHED rivet heads that will be acceptable are shown in Fig. 20.

PAR. 256 REVISED:

256 Rivets shall be SO DRIVEN AS [machine-driven wherever possible with sufficient pressure] to fill the [rivet] holes PREFERABLY BY A MACHINE WHICH MAINTAINS THE PRESSURE UNTIL NO PART OF THE HEAD SHOWS RED IN DAYLIGHT [and shall be allowed to cool and shrink under pressure]. Barrel pins fitting the holes and tack bolts to hold the plates firmly together shall be used. A rivet shall be driven each side of each tack bolt before removing the tack bolt.

PAR. 257 REVISED:

257 *Calking.* The calking edges of plates, butt straps and heads

FIG. 20½ CROSS-SECTION OF FLANGED MANHOLE FRAME

shall be beveled to an angle not sharper than 70 deg to the plane of the plate, and as near thereto as practicable. Every portion of the UNFINISHED [sheared] surfaces of the calking edges of plates, butt straps and heads shall be planed milled or chipped to a depth of not less than ⅛ in. Calking shall be done with a [roundnosed] tool OF SUCH FORM THAT THERE IS NO DANGER OF SCORING OR DAMAGING THE PLATE UNDERNEATH THE CALKING EDGE.

PAR. 258 REVISED:

258 *Manholes and Handholes.* An elliptical manhole opening shall be not less than 11 by 15 in., or 10 by 16 in. in size. A circular manhole opening shall be not less than 15 in. in diameter. A handhole opening in THE SHELL OF a boiler OR DRUM, the greatest dimension of which exceeds 6 in., shall be reinforced in accordance with the rules for manholes.

PAR. 260 REVISED:

260 Manhole frames on shells or drums when used, shall have the proper curvature, and on boilers over 48 in. in diameter shall be riveted to the shell or drum with two rows of rivets, which may be pitched as shown in Fig. 21. The strength of manhole frames and reinforcing rings shall be at least equal to the tensile strength (REQUIRED BY PAR. 180) of the maximum amount of the shell plate removed by the opening and rivet holes for the reinforcement on any line parallel to the longitudinal axis of the shell through the manhole, or other opening. WHEN A FLANGED MANHOLE FRAME IS USED THE FLANGED PORTION OF THE FRAME MAY BE CONSIDERED AS REINFORCEMENT UP TO A HEIGHT (h) OF THREE TIMES THE FLANGE THICKNESS (SEE FIG. 20½).

PAR. 261 REVISED:

261 The strength of the rivets in shear on each side of a manhole frame or reinforcing ring shall be at least equal to the tensile strength of the maximum amount of the shell plate removed by the opening

and rivet holes for the reinforcement on any line parallel to the longitudinal axis of the shell, through the manhole, or other opening, SUCH AS THOSE CUT FOR STEEL NOZZLES AND BOILER FLANGES, OVER 3-IN. PIPE SIZE.

PAR. 268 REVISED:

268 *Threaded Openings.* ALL PIPE THREADS SHALL CONFORM TO THE AMERICAN PIPE STANDARD AND ALL [a pipe] connections 1 in. in diameter or over shall have not less than the number of threads given in Table 8.

If the thickness of the material in the boiler is not sufficient to give such number of threads, the opening shall be reinforced by a pressed steel, cast steel, or bronze composition flange, or plate, so as to provide the required number of threads.

When the maximum allowable working pressure exceeds 100 lb. per sq. in., a NOZZLE OR SADDLE FLANGE [connection] riveted to the boiler to receive a flanged fitting shall be used for all pipe openings over 3-in. pipe size.

IF SPECIAL REDRAWN PIPE, NOT TO EXCEED $1^1/_2$ IN. STANDARD PIPE SIZE MADE FROM LAPWELDED IRON OF PUDDLED STOCK AND TESTED TO 1000 LB. HYDRAULIC PRESSURE, IS USED IN WATER-TUBE OR PORCUPINE BOILERS FOR A WORKING PRESSURE NOT TO EXCEED 200 LB. PER SQ. IN., WHEN SCREWED IN THE SHEET, WHICH HAS A WALL THICKNESS AT LEAST 50 PER CENT GREATER THAN THE WALL THICKNESS REQUIRED BY THE CODE FOR TUBES OF WATER-TUBE BOILERS, THE MINIMUM NUMBER OF THREADS SHALL CONFORM WITH THE VALUES GIVEN IN TABLE 8 AND THE CLOSED ENDS OF THE STUB TUBES MAY BE WELDED BY THE FORGING PROCESS.

PAR. 269 REVISED:

269 *Safety Valve Requirements.* Each boiler RATED TO DISCHARGE OVER 2000 LB. OF STEAM PER HOUR AT THE ALLOWED PRESSURE shall have two or more safety valves WHEN THE GENERATING CAPACITY OF THE BOILER EXCEEDS 2000 LB. PER HOUR. THE METHOD OF COMPUTING THE STEAM GENERATING CAPACITY OF THE BOILER SHALL BE AS GIVEN IN PAR. 421 OF THE APPENDIX [except a boiler for which one safety valve having a relieving capacity of 2000 lb. per hour or less, is required by the rules].

PAR. 272 REVISED:

272 ALL safety valves shall be SO CONSTRUCTED THAT NO SHOCKS DETRIMENTAL TO THE VALVE OR TO THE BOILER ARE PRODUCED [of such a type that] AND SO THAT no failure of any part can obstruct the free and full discharge of steam from the valve. Safety valves may be of the direct spring-loaded pop type with seat and bearing surface of the disk inclined at any angle between 45 deg. and 90 deg. to the center line of the spindle. The valve shall be rated at a pressure 3 per cent in excess of that at which the valve is set to blow.

Safety valves may be used which give any opening up to the full discharge capacity of the area of the opening at the base of the valve, provided the movement of the valve is gradual so as not to induce lifting of the water in the boiler.

[All safety valves shall be so constructed that no detrimental shocks are produced through the operation of the valve.] Weighted lever safety valves shall not be used.

PAR. 273 REVISED:

273 Each safety valve 1 IN. SIZE AND LARGER shall be plainly marked by the manufacturer IN SUCH A WAY THAT THE MARKINGS WILL NOT BE OBLITERATED IN SERVICE. The markings may be stamped on the body, cast on the body, or stamped or cast on a plate or plates permanently secured to the body, and shall contain the following:

a The name or identifying trademark of the manufacturer
b The nominal diameter
c The steam pressure at which it is set to blow
(*d* Blow down, or difference between the opening and closing pressures)
(*e*) *d* The weight of steam discharged in pounds per hour at a pressure 3 per cent higher than that for which the valve is set to blow
(*f*) *e* A.S.M.E. Std.

PAR. 274 REVISED:

274 The MINIMUM AGGREGATE [total] relieving capacity of ALL OF the safety valve or valves required on a boiler shall be not less than that determined on the basis of 6 lb. of steam per hour per sq. ft. of boiler heating surface for water-tube boilers. For all other types of power boilers, the total relieving capacity shall be not less than that determined on the basis of 5 lb. of steam per hour per sq. ft. of boiler heating surface. IN MANY CASES A GREATER RELIEVING CAPACITY OF SAFETY VALVES WILL HAVE TO BE PROVIDED THAN THE MINIMUM SPECIFIED BY THIS RULE AND IN EVERY CASE THE REQUIREMENT OF PAR. 270 SHALL HOLD. [For boilers with maximum allowable working pressures above 100 lb. and on the basis of 3 lb. of steam per hour per sq. ft. of boiler heating surface for boilers with maximum allowable working pressures at or below 100 lb. per sq. in.]

The heating surface shall be computed for that side of the boiler surface exposed to the products of combustion, exclusive of the superheating surface. In computing the heating surface for this purpose, only the tubes, fireboxes, shell, tube sheets and the projected area of headers need be considered. The minimum number and size of safety valves required shall be determined on the basis of the total relieving capacity and the relieving capacity marked on the valves by the manufacturer. WHERE THE FIRING CONDITIONS ARE CHANGED TO INCREASE THE RATE OF STEAM GENERATION, THE SAFETY VALVE CAPACITY SHALL BE INCREASED TO MEET THE NEW CONDITIONS AND BE IN ACCORDANCE WITH PAR. 270.

PAR. 275 REVISED:

275 IF THE SAFETY VALVE CAPACITY CANNOT BE COMPUTED, OR IF IT IS DESIRABLE TO PROVE THE COMPUTATIONS, IT [Safety valve capacity] may be checked in any one of the three following ways, and if found insufficient, additional capacity shall be provided:

[remainder of paragraph unchanged]

PAR. 276 REVISED:

276 When two or more safety valves are used on a boiler, they may be either separate or twin valves made by mounting individual valves on Y-bases, or duplex, triplex or multiplex valves having two or more valves in the same body casing. THE VALVES SHALL BE MADE OF EQUAL SIZES, IF POSSIBLE, AND IN ANY EVENT IF NOT OF THE SAME SIZE, THE SMALLER OF THE TWO VALVES SHALL HAVE A RELIEVING CAPACITY OF AT LEAST 50 PER CENT OF THAT OF THE LARGER VALVE.

PAR. 277 REVISED:

277 The safety valve or valves shall be connected to the boiler independent of any other steam connection, and attached as close as possible to the boiler, without any unnecessary intervening pipe or fitting. SUCH INTERVENING PIPE OR FITTING, IF USED, SHALL NOT BE LONGER THAN THE FACE TO FACE DIMENSION OF THE AMERICAN EXTRA-HEAVY IRON FLANGED TEE FITTING OF CORRESPONDING SIZE SHOWN IN TABLE 17 AND FIG. 33. Every safety valve shall be connected so as to stand in an upright position, with spindle vertical, when possible.

PAR. 278 REVISED:

278 Each safety valve shall have AT LEAST A full-sized direct connection to the boiler. No valve of any description shall be placed between the safety valve and the boiler, nor on the discharge pipe between the safety valve and the atmosphere. When a discharge pipe is used, it shall be not less than the full size of the valve, and shall be fitted with an open drain to prevent water from lodging in the upper part of the safety valve or in the pipe. EACH VALVE SHALL HAVE AN OPEN DRAIN TAPPED FOR DRIP PIPE THROUGH THE CASING BELOW THE LEVEL OF THE VALVE SEAT. IN THE CASE OF FIRE-TUBE BOILERS, THE SAFETY VALVE OPENINGS SHALL BE NOT LESS THAN THOSE CORRESPONDING TO SAFETY VALVES HAVING THE INTERMEDIATE LIFTS AND CORRESPONDING RELIEVING CAPACITIES GIVEN IN TABLE 15.

PAR. 279 REVISED:

279 If a muffler is used on a safety valve it shall have sufficient outlet area to prevent back pressure from interfering with the proper operation and discharge capacity of the valve. The muffler plates or other devices shall be so constructed as to avoid any possibility of restriction of the steam passages due to deposit. When an elbow is placed on a safety valve discharge pipe, it shall be located close to the safety valve outlet or the pipe shall be securely anchored and supported. All safety valve discharges shall be so located or piped as to be carried clear from running boards or working platforms

used in controlling the main stop valves of boilers or steam headers.

Where discharge pipes are used, THEY SHALL BE AS SHORT AND AS STRAIGHT AS POSSIBLE AND the cross-sectional area at any point shall be at least equal to the combined areas of the discharge outlets of the valves discharging therethrough. Ample drainage shall be provided at or near each safety valve and where the water of condensation may collect.

PAR. 280 REVISED:

280 When a boiler is fitted with two or more safety valves on one connection, this connection to the boiler shall have a cross-sectional area not less than the combined area BASED ON THE NOMINAL DIAMETERS of all of the safety VALVE CONNECTIONS [valves with which it connects].

PAR. 281 REVISED:

281 Safety valves shall operate without chattering and shall be set and adjusted as follows: To close after blowing down not more than 4 PER CENT NOR LESS THAN 2 PER CENT OF THE SET PRESSURE, BUT NOT LESS THAN 2 LB. IN ANY CASE. [4 lb. on boilers carrying an allowed pressure less than 100 lb. per sq. in. gage. To close after blowing down not more than 6 lb. on boilers carrying pressures between 100 and 200 lb. per sq. in. gage inclusive. To close after blowing down not more than 8 lb. on boilers carrying over 200 lb. per sq. in. gage.]

PAR. 282 REVISED:

282 To insure the valve being free, each safety valve shall have a substantial lifting device by which the valve may be raised from its seat at least $\frac{1}{16}$ in. when there is no pressure on the boiler. THE VALVE SHOULD NOT BE LIFTED UNLESS THERE IS SUFFICIENT STEAM PRESSURE ON THE BOILER TO BLOW ALL DIRT AND SCALE CLEAN FROM THE SEAT.

PAR. 286 REVISED:

286 A safety valve over 3 in. size, used for pressures greater than 15 lb. per sq. in. gage, shall have a flanged inlet connection The dimensions of flanges subjected to boiler pressure shall conform to the American Standard given in Table [8] [16 and] 17 of the Appendix [for the pressures therein specified], except that the face of the safety valve flange and the nozzle to which it is attached may be flat and without the raised face for pressures up to an including 250 lb. per sq. in. For higher pressures, the raised face shall be used.

PAR. 287 REVISED:

287 When the valve body is marked [with the letters A.S.M.E. Std.] as required by Par. 273, this shall be a guarantee by the manufacturer that the valve conforms to the details of construction herein specified.

PAR. 289 REVISED:

289 Every safety valve used on a superheater, discharging superheated steam, shall have a steel body INCLUDING ALL PARTS WHICH COME IN CONTACT WITH THE STEAM BETWEEN THE INLET AND OUTLET, with a flanged inlet connection, and shall have the seat and disk of nickel composition or equivalent material, and the spring fully exposed outside of the valve casing so that it shall be protected from contact with the escaping steam.

PAR. 290 REVISED:

290 Every boiler shall have proper outlet connections for the required safety valve or valves, independent of any other outside steam connection, the area of opening to be at least equal to the aggregate [nominal] area BASED ON NOMINAL DIAMETERS of all of the safety valves to be attached thereto. An internal collecting pipe, splash plate or pan may be used, provided the total area for inlet of steam thereto is not less than TWICE [one and one-half times] the aggregate area of the CORRESPONDING NOMINAL DIAMETERS OF THE attached safety valves. The holes in such collecting pipes shall be at least $\frac{1}{4}$ in. in diameter and the least dimension in any other form of opening for inlet of steam shall be $\frac{1}{4}$ in.

PAR. 299 CANCEL PRESENT WORDING OF REVISION AS PUBLISHED IN JULY ISSUE OF MECHANICAL ENGINEERING AND SUBSTITUTE THE FOLLOWING:

299 *Fittings.* FLANGED CAST IRON PIPE FITTINGS INCLUDING THOSE FOR STEAM AND FOR FEED WATER AND WHERE THE PRESSURES DO NOT EXCEED 160 LB. SHALL CONFORM TO THE AMERICAN STANDARD GIVEN IN THE APPENDIX. IF THE FITTINGS ARE BELOW THE WATER LINE THEY SHALL BE EXTRA HEAVY.

FOR PRESSURES EXCEEDING 160 LB. PER SQ. IN., FITTINGS MORE THAN 2 IN. PIPE SIZE OR EQUIVALENT CROSS SECTIONAL AREA, SHALL BE OF CAST OR FORGED STEEL. (SEE PARS. 9 AND 245.) THE DIMENSIONS OF THE FLANGES AND DRILLING SHALL CONFORM TO THE AMERICAN STANDARD GIVEN IN TABLE 17.

FOR PRESSURES EXCEEDING 250 LB. PER SQ. IN., THE FLANGE THICKNESS, AND THE THICKNESS OF THE BODIES SHALL BE INCREASED TO GIVE AT LEAST THE SAME FACTOR OF SAFETY AS THE FITTINGS SPECIFIED IN THE TABLE, WHEN USED FOR THE MAXIMUM PRESSURES PERMITTED IN THE CODE.

THE FACE OF THE FLANGE OF A SAFETY VALVE, AS WELL AS THAT OF A SAFETY VALVE NOZZLE MAY BE FLAT AND WITHOUT THE RAISED FACE, FOR PRESSURES NOT EXCEEDING 250 LB. BUT SHALL HAVE THE RAISED FACE FOR HIGHER PRESSURES.

THE NUMBER OF BOLTS IN A FLANGE MAY BE INCREASED, PROVIDED THEY ARE LOCATED ON THE STANDARD BOLT CIRCLE. OTHER EXCEPTIONS ARE NOTED IN PAR. 12. TABLES 16 AND 17 DO NOT APPLY TO FLANGES ON THE BOILER SIDE OF STEAM NOZZLES, OR TO FLANGES LEFT BY THE MANUFACTURER AS PART OF THE BOILER, AND DO NOT APPLY TO FITTINGS DESIGNED AS PART OF THE BOILER.

PAR. 306 REVISED:

306 Each superheater shall be EQUIPPED [fitted] with AT LEAST ONE drain SO LOCATED AS WILL MOST EFFECTIVELY PROVIDE FOR THE PROPER OPERATION OF THE APPARATUS.

PAR. 311*a* REVISED:

311*a* On all boilers except those used for traction and portable purposes, when the maximum allowable working pressure exceeds 125 lb. per sq. in., each bottom blow-off pipe shall have two valves, or a valve and a cock, and such valves, or valve and cock, shall be OF extra heavy CONSTRUCTION. [except that.] On a boiler having multiple blow-off pipes, a single master valve may be placed on the common blow-off pipe from the boiler, in which case only one valve on each individual blow-off is required. TWO INDEPENDENT VALVES OR A VALVE AND A COCK MAY BE COMBINED IN ONE BODY PROVIDED THE COMBINED FITTING IS THE EQUIVALENT OF TWO INDEPENDENT VALVES OR A VALVE AND A COCK SO THAT THE FAILURE OF ONE TO OPERATE COULD NOT AFFECT THE OPERATION OF THE OTHER.

PAR. 312 REVISED:

312 A bottom blow-off pipe when exposed to direct furnace heat shall be protected by fire-brick, OR OTHER HEAT RESISTING MATERIAL SO ARRANGED THAT THE PIPE MAY BE INSPECTED [a substantial cast iron removable sleeve or a covering of non-conducting material].

PAR. 314 CANCEL PRESENT WORDING OF REVISION AS PUBLISHED IN JULY ISSUE OF MECHANICAL ENGINEERING AND SUBSTITUTE THE FOLLOWING:

314 THE FEED WATER SHALL BE INTRODUCED INTO A BOILER IN SUCH A MANNER THAT THE WATER WILL NOT BE DISCHARGED DIRECTLY AGAINST SURFACES EXPOSED TO GASES OF HIGH TEMPERATURE, OR TO DIRECT RADIATION FROM THE FIRE, OR CLOSE TO RIVETED JOINTS OF SHELL OR FURNACE SHEETS.

PAR. 315 OMIT FIRST SECTION OF REVISION AS PUBLISHED IN AUGUST ISSUE OF MECHANICAL ENGINEERING, AND RETAIN LAST SECTION OF PARAGRAPH AS FOLLOWS:

315 In Fig. 22 is illustrated a typical form of flange for use on boiler shells for passing through piping such as feed, surface, blow-off connections, etc., and which permits of the pipes being screwed in solid from both sides in addition to the reinforcing of the opening in the shell.

PAR. 316 CANCEL PRESENT WORDING IN BOILER CODE AND REPLACE BY SECOND SECTION OF REVISED PAR. 315 AS PUBLISHED, AS FOLLOWS:

316 IN THESE AND other types of boilers where both internal and external pipes making a continuous passage are employed, the boiler bushing or its equivalent shall be used.

PAR. 321 REVISED:

321 The water connections to the water column of a boiler [shall be of brass] WHEN PRACTICAL, shall be provided with a cross

AT EACH RIGHT-ANGLE TURN to facilitate cleaning. FOR PRESSURES OF 200 LB. STEAM PRESSURE OR LESS, THE WATER CONNECTION, IF PIPE IS USED, SHALL BE OF BRASS.

PAR. 323 REVISED:

323 *Methods of Support.* A horizontal-return-tubular boiler over 78-in. in diameter shall be supported from steel lugs by the outside suspension type of setting, independent of the boiler side walls. The lugs shall be so designed that the load is properly distributed between the rivets attaching them to the shell and so that no more than two of these rivets come in the same longitudinal line on each lug. The distance girthwise of the boiler from the centers of the bottom rivets to the centers of the top rivets attaching the lugs shall be not less than 12 in. The other rivets used shall be spaced evenly between these points. If more than four lugs are used they shall be set in four pairs, THE LUGS OF EACH PAIR TO BE SPACED NOT OVER 2 IN. APART AND THE LOAD TO BE EQUALIZED BETWEEN THEM. (SEE FIG. 22¾.)

PAR. 324 REVISED:

324 A horizontal return tubular boiler 14 FT. OR MORE IN LENGTH, over 54 in. and up to and including 78 in. in diameter, shall be supported by the outside suspension type of setting, or at

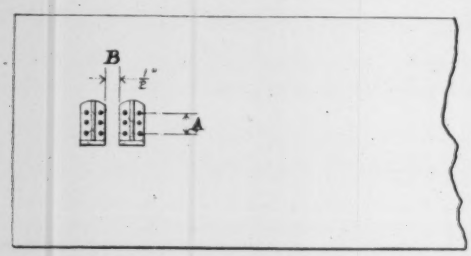


FIG. 22¾ SPACING OF SUPPORTING LUGS IN PAIRS ON H.R.T. BOILERS

four points by not less than eight steel or cast-iron brackets set in pairs.

PAR. 328 REVISED:

328 A water-tube boiler shall have the firing doors, furnace inspection doors and clinker doors of the inward-opening type, unless such doors are provided with substantial and effective latching or fastening devices OR OTHERWISE SO CONSTRUCTED AS to prevent them WHEN CLOSED from being blown open by pressure on the furnace side.

PAR. 332 REVISED:

332 Each boiler shall conform in every detail to these Rules, and shall be distinctly stamped with the symbol as shown in Fig. 23, denoting that the boiler was constructed in accordance therewith.

After obtaining the stamp to be used when boilers are to be constructed to conform with the A.S.M.E. Boiler Code, a state inspector, municipal inspector, or an inspector employed regularly by an insurance company which is authorized to do a boiler insurance business in the state in which the boiler is built and in the state in which it is to be used, if known, is to be notified that an inspection is to be made and he shall inspect such boilers during construction and after completion. At least two inspections shall be made, one before reaming rivet holes and one at the hydrostatic test. In stamping the boiler after completion, if built in compliance with the code, the builder shall stamp the boiler in the presence of the inspector, after the hydrostatic test, with the A.S.M.E. Code stamp, the builder's name and the serial number of the manufacturer. A data sheet shall be filled out and signed by the manufacturer and the inspector. This data sheet together with the stamp on the boiler shall denote that it was constructed in accordance with the A.S.M.E. Boiler Code.

IN CASES WHERE BOILERS CANNOT BE COMPLETED AND HYDROSTATICALLY TESTED BEFORE SHIPMENT, THE PROPER STAMPINGS SHALL BE APPLIED AND TWO DATA SHEETS SIGNED AS HEREIN PROVIDED BY THE SAME OR DIFFERENT INSPECTORS COVERING THE PORTIONS OF THE INSPECTIONS MADE AT THE SHOP AND IN THE FIELD, THE DATA SHEETS EACH TO BE SEPARATELY SENT TO THE PROPER DESTINATION.

Each boiler shall be stamped adjacent to the symbol as shown in

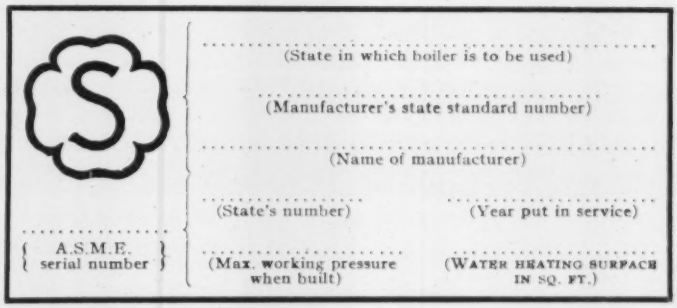

S
(State in which boiler is to be used)
(Manufacturer's state standard number)
(Name of manufacturer)
(State's number)
(Year put in service)
A.S.M.E. serial number
(Max. working pressure when built)
(WATER HEATING SURFACE IN SQ. FT.)

FIG. 24 FORM OF STAMPING

Fig. 24, with the following items with intervals of about one-half inch between the lines:

1 A.S.M.E. [Manufacturer's] serial number WHICH MAY BE THE MANUFACTURER'S SERIAL NUMBER
2 State in which boiler is to be used
3 Manufacturer's State standard number
4 Name of manufacturer
5 State's number
6 Year put in service
7 Maximum working pressure when built
8 WATER HEATING SURFACE IN SQ. FT.

Items 1, 2, 3, 4, 7 AND 8 are to be stamped at the shop where built.

Items 5 and 6 are to be stamped by the proper authority at point of installation.

PAR. 351 OMIT THIS PARAGRAPH.

TABLE 15 ADD FOLLOWING NOTE AT END OF THIS TABLE:

THIS TABLE SHOWS THE COMPUTED RELIEVING CAPACITIES FOR SAFETY VALVES OF VARIOUS SIZES AND IS INTENDED FOR REFERENCE ONLY. HOWEVER, THERE IS NO LIMIT SET IN THE CODE TO THE AMOUNT THE SAFETY VALVE MAY LIFT, PROVIDED THE VALVE OPERATES PROPERLY, AND IT MAY BE THAT THE RELIEVING CAPACITY STAMPED ON THE VALVE BY THE MANUFACTURER WILL BE GREATER THAN ANY OF THOSE GIVEN IN THIS TABLE.

PAR. 429 REVISED:

429 The least diameter of fusible metal shall be not less than ½ in., except for maximum allowable working pressures of over 175 lb. per sq. in. or when it is necessary to place a fusible plug in a tube, in which case the least diameter of fusible metal shall be not less than ⅜ in. IF A FUSIBLE PLUG IS INSERTED IN A TUBE THE TUBE WALL SHALL BE NOT LESS THAN 0.22 IN. THICK OR SUFFICIENT TO GIVE FOUR THREADS.

PAR. 430 *r* REVISED:

r In Economic Type Boilers—in the rear head, NOT LESS THAN 2 IN. above the upper row of tubes.

REVISE PAR. L-18 AND TABLE L-2 OF LOCOMOTIVE CODE AS FOLLOWS:

Par. L-18 Change second paragraph to read: In the case of superheater flues which are expanded [the gage of], the expanded end may be ½ [1½] gage [s] lighter and the swaged end THREE [two] gages heavier than the gage thickness SPECIFIED.

Table L-2 Change title to read: MINIMUM Gage Thickness of Walls of Fire Tubes or Flues.

All gage thickness numbers in table to be increased by one, i.e., in place of 7 insert 8, in place of 8 insert 9, etc. Omit note under table.

Work of A.S.M.E. Boiler Code Committee

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the

Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING.

Below are given the interpretations of the Committee in Cases Nos. 395, 397, 406 and 407, as formulated at the meeting of September 20, 1922, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

CASE NO. 395

(Annulled)

CASE NO. 397 (Reopened)

Inquiry: Was it the intent, in Par. 199, to permit a value of 175 for C where copper washers were used as described in the definition for C?

Reply: It is the opinion of the Committee that the washers should be of steel to permit the use of 175 for C. Copper washers may be used provided the value of C is taken the same as if no washer were used.

CASE NO. 406

Inquiry: Will a form of forged steel boiler nozzle with flange pressed hot over the end neck of the nozzle which is compressed or forged into a recess or groove in the flange conform to the requirements of the Code?

Reply: It is the opinion of the Committee that this method of forming a steam outlet connection meets the requirements of the Rules in the Boiler Code.

CASE NO. 407

Inquiry: Is it permissible under the Rules of the Code for Boilers of Locomotives to mark a safety valve A.S.M.E. Std., when it is not fitted with a lifting device, whereas Par. 282 of the Power Boiler section of the Code requires such a lifting device?

Reply: Inasmuch as Par. 282 of the Power Boiler section of the Code requires a lifting device and there is no similar requirement in the section of the Code for Boilers of Locomotives, it is the opinion of the Committee that safety valves for use in stationary service under the Power Boiler Rules must be fitted with a lifting device and those intended for use on boilers of locomotives need not have such a lifting device, and that it is proper in each case to mark the safety valve A.S.M.E. Std.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Department of MECHANICAL ENGINEERING are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities and policies of the Society in Research and Standardization.

Castings Direct from the Ore as Made at the Rouge Plant of the Ford Motor Company

TO THE EDITOR:

The author of an article entitled Making High-Grade Castings Direct from the Ore, an abstract of which appears in MECHANICAL ENGINEERING for October, 1922, page 660, seems to have been misinformed. Since the article as it stands might mislead some member of our engineering fraternity, the following is offered as a correct outline of the practice at the Rouge Plant of the Ford Motor Company.

The line of blast furnaces lies 225 ft. west of the parallel line of 24 cupolas of 78 in. diameter, shell-lined to 60 in. The cupolas are divided into three batteries of eight stacks each. Pollock 75-ton, 3-trunnion, elliptical ladles on railroad trucks take the hot metal from the blast furnace on to the track west of the foundry parallel to the line of cupolas. A 100-ton Wellman-Seaver-Morgan ladle tilting gantry crane running on broad-gage track straddles the ladle cars.

Three pairs of Pollock 30-ton hot-metal containers originally took the blast-furnace metal from the 75-ton ladles to the 1-ton ladle line which runs in front of the cupolas. These 30-ton containers are built of steel plate, entirely closed except at the filling hole and pouring spout, and have the ordinary refractory lining. They were filled at the tilting crane alternately and run to the pouring stands. Twenty-ton trolleys lifted the containers off their cars at the rear and tilted them about their pouring spouts to serve the 1-ton ladles. So much for the blast-furnace metal.

The foundry scrap, sprues, gates, special pig, steel scrap, etc. are melted in the cupolas.

The one-ton ladles from which the molds were poured ran to the monorail scales at the 30-ton container, received about half a ton of blast-furnace metal, ran to the adjacent cupolas and received another half-ton of cupola metal, and then ran to the pouring lines of the mold conveyors.

This method is being gradually modified. At No. 1 division the 30-ton container remains at the pouring stand and is served from the 75-ton ladle by two 15-ton Whiting ladles. A gas burner in the 30-ton container keeps the metal hot. At No. 2 division two ladles of about 10 tons capacity will soon be used to receive blast-furnace metal from the 75-ton ladle and to pour into the 1-ton ladles without any 30-ton container. At No. 3 division, one 10-ton ladle is used between the 75-ton ladle and the 1-ton pouring ladles.

The layout at No. 2 will probably be final for both large and small molding of automobile and tractor parts. If cold metal is experienced a gas burner can be placed in the 75-ton ladle, but this will probably not be required.

Although a vacuum-walled container may have been contemplated by the Experiment Department, it would seem to be extremely impracticable, and is wholly unknown to the Foundry Engineering Department.

CLARENCE A. BROCK.

Detroit, Mich.

The Surge-Tank Problem

TO THE EDITOR:

Referring to the letter from Mr. Jakobsen, appearing in the November issue of MECHANICAL ENGINEERING, his claim that the differential surge tank is not usually the best design for low- or medium-high-head plants indicates, on the face of it, that he has something better to offer, and I am sure that the many users of this method of regulation in the United States and Canada will look forward with interest to the publication of the article which he says is forthcoming.

Inasmuch as a shortage in power has been so flatly attributed to the use of the differential principle, it may be of engineering interest to set forth a contrary point of view, even before discovering what Mr. Jackobsen would "generally" recommend in place of the differential surge tanks, which have been so frequently adopted.

For this purpose it may be pertinent once more to compare a simple surge tank with a differential under precisely the same physical conditions: that is to say, the two areas must be the same and the plant must be fully loaded at the bottom of a large surge occurring in a differential regulator. The internal riser pipe is then to be considered removed, leaving a simple surge tank with un-

restricted connection to the conduit and comparison made with the former case.

It will be seen at once that it is only fair to regard the plant as fully loaded under the most unfavorable head occurring at the "critical moment" when the water level in the riser is lowest, for otherwise there would still be power available for sale, which does not seem to furnish a sound economic basis for comparison.

If the simple tank now be subjected to the same load change which has been successfully sustained by the differential regulator, it is probably only necessary to point out that the turbines would not be able to carry the load at the bottom of the resulting surge because it would be much larger than in the former case, thus inviting the governor to try to open the gates beyond their wide-open position, with a consequent drop in speed of prohibitive amount.

In this case the shortage in power would last so long before the water surface rose enough to furnish the required head that no one would even consider the possibility of tiding over this large gap by means of flywheel effect. In other words, the flywheel is intended to help carry the load only during acceleration of the water in the comparatively short penstocks between the regulator and the turbines, and not during the long time required to accelerate the water in the long conduit. The surge tank is the "flywheel" for the latter purpose.

It is just possible that Mr. Jakobsen has confused these two ideas, because the only shortage of power resulting from the use of a differential regulator, so far as I know, is that which makes a theoretically greater call upon the flywheel during and sometimes shortly after the first quick impulse of the governor following a sudden load change.

This shortage of power is recognized and understood and provides the excuse for the flywheel, which, of course, when properly proportioned in connection with the area of the riser pipe and the ports controlling the outflow from the tank, does not mean a material net shortage of power delivered to the bus bars, and this is the only concern we have in this connection.

To attempt to discredit the economy of a differential regulator because it drops the penstock power a trifle more than does a simple tank during and only during the extremely short impulse period above referred to, would be, to my mind, to lose a proper sense of proportion. In other words, this disadvantage must be vastly augmented in the imagination before it gains a place in a practical mind beyond a purely academic point.

I do not mean to intimate that this is the "shortage" to which Mr. Jakobsen refers, but I mention it because I can think of no other, and he has made it necessary for me to hunt as diligently as possible for a sound basis for his sweeping statement.

It should be noted that the foregoing comparisons have particular reference to a sudden load change of somewhat unusual magnitude and also to low- and medium-high heads, or, to the very conditions under which, according to Mr. Jakobsen, the differential regulator fails to give a good account of itself.

It might be added that the differential regulator properly designed is not intended to exercise its full or ideal differential action except for the very largest load change selected by judgment as that beyond which good speed regulation is of no consequence because of too infrequent occurrence.

For load changes of half this maximum the differential action already largely disappears, and therefore—almost all the time in most cases—any academic advantage attributed to the simple tank is shared equally by the other.

The many advantages of the differential regulator have been set forth so long ago and have been criticized and studied by so many able engineers both in this country and abroad, that it seems hardly worth while to point them out again in this discussion.

The cone-shaped tank to which Mr. Jakobsen refers seems to me to owe some of its virtue to a diffident approach toward the idea of a faster-dropping water level during the early part of the surge which is the vital principle of differential action. This idea is, however, the one he condemns as producing "shortage of power at some critical moment," and therefore it will be of general interest to find out by what means he proposes to improve upon or replace the differential regulator in most cases of low- or medium-high-head plants.

The conical shape has an advantage in some cases in providing a greater area at times of low water in the pond, but it is equally applicable to the tank of a differential regulator and presents a virtue quite apart from the matter under discussion.

It should be remembered that the drop of water level in the riser is anything but sudden as compared to the time for the governor to make an initial adjustment of the turbine gates.

In closing, I wish to invite Mr. Jakobsen and others to a very full public discussion of the points which he has raised, and to avoid lost motion and confusion, I would like to suggest that great care be used in selecting any numerical examples as a means of demonstration, so that they will represent normal conditions and the best principles of design for the accomplishment of a stated purpose.

R. D. Johnson.

New York, N. Y.

Mathematical Determination of the Modulus of Elasticity

To the Editor:

The method for determining the modulus of elasticity herein elucidated has for its *raison d'etre* extreme simplicity, combined with mathematical precision, eliminating the necessity of measuring minute elongations under heavy loads.

In Fig. 1 CAD represents a light strip of the material to be tested,

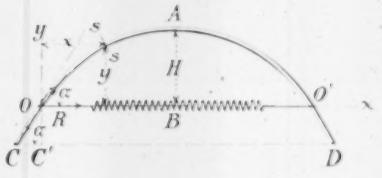


Fig. 1

of uniform cross-section, easily yielding to a certain amount of bending within its elastic limit, and resting freely in a horizontal plane, for the elimination of vertical-load influences.

B is a common spring balance or scale, such as can be found in any hardware store, forming part of the cord holding the points O and O' of the strip in its bent position, as shown, and indicating the existing tension R along the cord OO'.

The strip to be tested is extended to the points C and D below the cord OO' for reasons that will become clear later.

For the cross-section s-s of the strip with its coördinates x, y, the moment M of the external forces is Ry; the moment of resistance of the cross-section s-s is EI/ρ, E denoting the modulus of elasticity, I the moment of inertia of the cross-section of the strip, and ρ the radius of curvature at the section s-s. Replacing the curvature $1/\rho$ by its expression—

$$\frac{\dfrac{\partial^2 y}{\partial x^2}}{\left[1+\left(\dfrac{\partial y}{\partial x}\right)^2\right]^{1/2}}$$

we obtain the equation—

$$-M = -Ry = +\frac{EI}{\rho} = EI\,\frac{\dfrac{\partial^2 y}{\partial x^2}}{\left[1+\left(\dfrac{\partial y}{\partial x}\right)^2\right]^{1/2}} \quad \ldots\ldots [1]$$

which shows that the bending curve cannot be a circular arc, the curvature varying with y. The minus sign is taken before M, because $\partial y/\partial x$ being the tangent of the angle of the curve element with the axis Ox, decreases with x, hence $\partial^2 y/\partial x^2$ is negative.

Multiplying both members in Equation [1] by $2(\partial y/\partial x)\,dx$ and integrating, we obtain:

$$R\int 2y\,\frac{\partial y}{\partial x}\,dx = -EI\int \frac{2\,\dfrac{\partial y}{\partial x}\cdot\dfrac{\partial^2 y}{\partial x^2}\cdot dx}{\left[1+\left(\dfrac{\partial y}{\partial x}\right)^2\right]^{1/2}}$$

or

$$Ry^2 = \frac{2EI}{\sqrt{1 + \left(\frac{\partial y}{\partial x}\right)^2}} + C \quad \ldots\ldots\ldots\ldots [2]$$

For the point O of intersection of the strip with the cord, $y = 0$, and $\partial y/\partial x$ becomes $\tan \alpha$, where α is the angle of the curve element with the cord OO' at the point O. Hence for that point Equation [2] becomes—

$$O = \frac{2EI}{\sqrt{1 + \tan^2\alpha}} + C; \quad \text{or} \quad C = -2EI \cos \alpha$$

Introducing the obtained expression for C into [2], we obtain—

$$Ry^2 = 2EI\left(\frac{1}{\sqrt{1 + \left(\frac{\partial y}{\partial x}\right)^2}} - \cos \alpha\right) \quad \ldots\ldots\ldots [3]$$

Now, for the apex A of the curve, $y = H$, $\partial y/\partial x = 0$, and [3], applied to the cross section at A, becomes—

$$RH^2 = 2EI(1 - \cos \alpha) \quad \ldots\ldots\ldots\ldots [4]$$

The angle α entering in this equation is obtainable by direct linear measurements, and without the use of a protractor: that is to say the extension OC of the strip being straight, it must coincide with the tangent to the curve at point O, hence—

$$\cos \alpha = \frac{CC'}{OC'} = \frac{CD - OO'}{2OC}$$

To apply Equation [4] correctly, the test strip must become perfectly straight when the cord OO' is relaxed.

Let now the cord OO' be tightened up to an additional amount of tension ΔR, so that the spring balance will indicate $R + \Delta R$ tension, and the corresponding deformations of the test strip will be H_1 and α_1. Introducing these new notations into [4], we obtain—

$$(R + \Delta R)H_1^2 = 2EI(1 - \cos \alpha_1)$$

Multiplying this equation by H^2 and subtracting from it [4] multiplied by H_1^2 gives—

$$\Delta RH^2H_1^2 = 2EI[H^2(1 - \cos \alpha_1) - H_1^2(1 - \cos \alpha)] \quad \ldots [5]$$

In this equation ΔR is the cord tension corresponding not to the total deformation of the test strip, H_1 and α_1, but to the change in its deformation from H and α to H_1 and α_1. Hence Equation [5], unlike Equation [4], may be applied to a test strip that is already partly bent and curved, which is of great advantage, as it eliminates the necessity of using a perfectly straight strip and keeps the bending within the elastic limit. Instead, a partly bent strip may be used, applying a small tension to produce but a slight change in its already existing large and easy-to-measure deformations.

From Equations [4] and [5] the modulus of elasticity E is easily determined, or any other factor, like R or I, may be determined when E is known from tables of the strength of materials.

The expression within the brackets in Equation [5] may become negative; then ΔR, too, would be negative; that is, by further tightening up the cord its tension R decreases instead of increases. That may happen in case the angle α is too large. Hence the testing strip should not be too much bent at the start.

Although as a matter of simplicity a spring balance is shown in the illustration as forming a part of the cord, in practice, however, it proves very clumsy, requiring strips that are both long and wide with holes drilled to let the cord through and obstructing correct measuring.

For that reason a suitable dynamometer has been designed, which is shown in Fig. 2 in the form it has been entered at the Patent Office. As seen, it consists of two extension clamps at the tops of which are inserted the ends of the testing strip, which may have the form of a thin band or of a round wire. The clamps are elongated and forked, forming extensions to the strip, and each has a pivoted square block inside the fork with holes in the center of the blocks through which passes freely a long rod having a bolt head at one end and a screw thread at the other. Between the bolt head and washer and the adjacent pivoted block a spring is mounted on the rod, surrounded by a cylindrical casing with two longitudinal slots and graduations marked alongside, as shown at A, Fig. 2. Through these slots pass the lugs of the washer, indicating the compression of the spring in pounds.

The threaded end of the rod is provided with a thumb nut and a set-screwed collar. Thus, the testing strip is held in its strained bent position at one end by the compression of the spring and at its other by the thumb nut with the rod between the two pivoted blocks forming the cord in tension.

The dimensions H, h, b, and c are convenient to measure and the cord tension in pounds is readily shown on the spring casing.

The deduction of the formulas is the same as before, except that at the end of the testing strip, at its entrance into the clamp, where $\partial y/\partial x$ becomes $\tan \alpha$, y is not 0, but equal to h, so that the constant $C = Rh^2 - 2EI\cos \alpha$, and Equations [3], [4] and [5] now become—

$$R(y^2 - h^2) = 2EI\left(\frac{1}{\sqrt{1 + \left(\frac{\partial y}{\partial x}\right)^2}} - \cos \alpha\right) \quad \ldots\ldots [3_1]$$

$$R(H^2 - h^2) = 2EI(1 - \cos \alpha) \quad \ldots\ldots\ldots\ldots [4_1]$$

$$\Delta R(H^2 - h^2)(H_1^2 - h_1^2) = 2EI[H^2 - h^2)(1 - \cos \alpha_1) - (H_1^2 - h_1^2)(1 - \cos \alpha)] \quad \ldots\ldots\ldots\ldots [5_1]$$

$$\cos \alpha = \frac{b - c}{2a}; \quad \cos \alpha_1 = \frac{b_1 - c_1}{2a}$$

The set-screwed collar, shown close to the thumb nut, serves for verifying whether the test has been carried on within the elastic

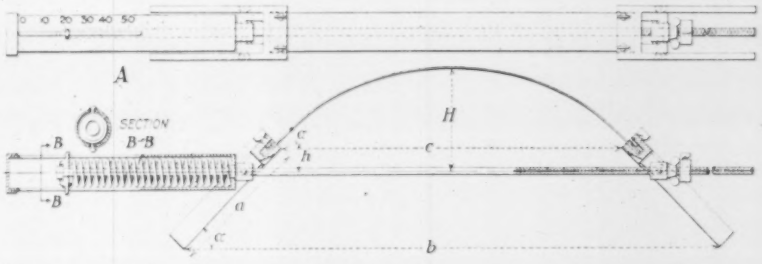


FIG. 2

limit or not: namely, setting the collar close to the thumb nut at the start of the test and noting the corresponding tension R of the spring when it is slightly compressed; then, if at the close of the test, when the pivoted block and thumb nut are brought again close to the set-screwed collar, the spring registers the same tension as at the start, the elastic limit has not been exceeded; if the tension is less than at the start, then the elastic limit has been exceeded, and the strip has lost part of its resisting tension.

The writer has applied Equation [4] to wooden strips of common white pine, using a common spring balance, and obtained E = 1,013,000, in one test, and E = 955,000 in another; the tables give E = 1,000,000, for white pine.

The tension T per unit area at any cross-section of the strip can easily be determined in the following manner: Replacing the third member in Equation [1] by $TI/0.5e$, where e is the thickness of the strip, both this term and EI/ρ expressing the same moment of resistance of the cross-section, we have the equation—

$$Ry = \frac{TI}{0.5e} \quad \ldots\ldots\ldots\ldots\ldots [6]$$

For the cross-section at the apex A, y becomes H and T becomes T_{max}, and—

$$RH = \frac{T_{max}I}{0.5e} \quad \ldots\ldots\ldots\ldots\ldots [7]$$

To apply these two equations correctly, the strip must become straight when the cord is relaxed.

Syracuse, N. Y. DAVID GUELBAUM.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

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Engineering and Economics

EVERY engineering problem has an economic phase of fundamental importance. Every machine, every power plant, every bridge and every mine operation must have some economic justification. This often imposes rigid restrictions upon the possible solutions of the engineering problem involved, making them more difficult. The engineer thus has a thorough appreciation of some of the principles of economics.

Progress in the establishment of our present-day civilization is due in no small part to the work of the engineer, and its maintenance and development are a matter of great responsibility for this profession which has stated its function as that of directing the use of men and materials for the service of mankind. To properly shoulder this responsibility and perform this function, the engineer must be prepared to take a broader interest in the economic problems of our political structure. He must have a deeper knowledge than is required to satisfy the economic demands of an engineering problem. He must understand the relation of his work to the production and distribution of the wealth of the world, and this will bring him face to face with those who have developed the principles of political economy.

It is no new realization that engineers must be well grounded in political economy. Engineering societies have discussed some parts of the subject and the technical press has devoted space to it. Technical schools are encouraging its study. But the first time that any organized attempt to gather engineers and economists together in any large way will occur at the coming Annual Meeting of The American Society of Mechanical Engineers, when a joint session will be held with the American Economic Association.

The program that has been announced for the session gives promise of great interest. The papers to be presented by Dr. Wesley C. Mitchell of Columbia University and E. M. Herr, President of the Westinghouse Electric and Manufacturing Company, with the discussion by leaders in both professions should develop the importance of mutual understanding by both groups and emphasize the desirability for a more permanent relation between them to encourage future joint discussion of economic problems.

In his paper, Dr. Mitchell establishes the intimate connection between the work of the engineer and that of the economist in the production of wealth. He tells of the parallel careers of James Watt, the inventor, and Adam Smith, the economist. He states the problems to be faced and holds out the hope of an adequate solution by the method of scientific analysis, so skilfully used by the engineer in the solution of his technical problems.

Mr. Herr will deal with the human phase of the process of producing wealth. The opening paragraphs of his paper show most surprisingly that the labor problems of today and conditions of over twenty-five centuries ago do not differ fundamentally except in the matter of background. He then establishes the importance of industry, evaluates the factors relating to the human problem in it, states the principles necessary for solution, and concludes in an appeal for the substitution of reason for force in the settlement of industrial disputes.

This program was arranged by the Management Division of The American Society of Mechanical Engineers and it is to be congratulated. The results of the meeting should be bountiful and far-reaching.

Coal Facts

THE appointment of the fact-finding commission for the coal industry will be welcomed by the engineering profession as the first step in the elimination of periodic interruptions which have meant severe inconvenience and which, if continued, will spell disaster to the comfort of the people of this country as well as to the industries.

Secretary Hoover has pointed out that the biennial struggles in the coal industry, which have hindered the necessary regular supply, are in part symptoms of a disease which should be treated from an accurate diagnosis of "facts." He has further pointed out that there are 2500 too many bituminous mines and 200,000 too many people in the business, with a resultant waste of labor and capital which levies tremendous tribute on the entire country. Intermittent operation resulting from this over-capacity and from labor disputes aggravates the coal-transportation difficulties. Stabilization of this industry, fundamental to our comfort and progress, must be achieved and the coal commission is charged with the duty of discovering the facts upon which proper legislation for the public welfare may be based.

The confidence which the engineering profession must have in the soundness of the proposed procedure is heightened by the appointment of two engineers as members of the commission. One of these is John Hays Hammond, chairman of the commission and the other is George Otis Smith who is Director of the United States Geological Survey. In a recent editorial comment on the personnel of the commission, *Mining and Metallurgy* makes the following statement:

> These two names alone relieve the mining industry of the dread that the commission to be appointed would bring in a more or less nebulous report which would be rejected by both the operators and the miners and leave the industry just where it was before.
>
> The other members of the commission are ex-Vice President Marshall, distinguished for his practical good sense and integrity; a sound lawyer, Judge Samuel Alschuler; a public-spirited editor, Clark Howell; Dr. Edward T. Devine, a social worker of national reputation, and Charles T. Neill, manager of the bureau of information of the Southeastern railways.
>
> This is an eminent body of men and the President and the people of the country are to be congratulated on their selection. No less fortunate are the mine operators and the miners themselves. The former are assured of an intelligent investigation of the intricate technical details of the mining business by two outstanding mining engineers whose integrity is as great as their ability.
>
> The appointment of Dr. George Otis Smith on this commission is a happy one for another reason. The Geological Survey is the greatest repository of facts and figures of the coal-mining industry in existence today and no commission could function without the aid of his department. Acting as a commissioner, he will be freed from the restraint imposed upon him as Direct of the Survey. This efficient machinery already functioning in the gathering of facts and statistics will very much expedite the work o the commission. Should these two outstanding members of our profession return findings which are surprising to the public and unpalatable to the coal operators, we shall at least be sure that there has been no thimblerigging which would accelerate our progress towards economic disaster in the country's most needful industry.

Great is the responsibility of this commission. Its opportunity for accomplishing an epoch-making work is boundless, and the engineering profession will follow its procedure with sympathy and profound interest.

Commercial Air Transportation Heralded at Detroit Congress

AN INTENSE desire to see aeronautics established on a safe and sane basis as a means of transportation was clearly expressed at the Second Aeronautical Congress held at Detroit, in October, when the National Aeronautical Association was formed. Prof. E. P. Warner represented The American Society of Mechanical Engineers on this occasion and reported that the bare statement of activities cannot adequately express the intensity of the interest shown in the new organization or the keenness of the desire of all those present that the National Aeronautical Association should be so established as to unite all elements and to play an important part in placing American aeronautics in a position where it can render strong and important service to the state, both in the military and in the economic spheres. Past animosities were forgotten and all elements worked together to lay a most encouraging foundation.

The week of the Detroit meeting was an important one for aeronautics. On Monday, October 11, the first National Air Institute was held under the auspices of the Detroit Aviation Society. The permanent chairman was Professor Herbert C. Sadler of the University of Michigan, and he presided over a program arranged by a Committee representing the National Advisory Committee for Aeronautics, Society of Automotive Engineers, The American Society of Mechanical Engineers, and the Aeronautical Chamber of Commerce of America, Inc.

In his opening remarks Professor Sadler emphasized the importance of transportation as the primary factor in the advance of civilization. Today it is the keynote of commercial enterprise, often the governing factor in the success or failure of almost any business. There is in history an inexorable demand for increase in speed, and on land and sea our speed limits are nearly reached. In the air, however, we can obtain speeds even in excess of those on land and sea and with a relatively moderate expenditure of power.

Dr. Joseph S. Ames contributed discussion on the importance of scientific investigation in the general aeronautical program. Lewis E. Pierson, President of the Merchants' Association of New York City, clarified the relation between commercial aviation and the commercial bank. Charles F. Redden, Governor of the Aeronautical Chamber of Commerce of America, indicated the advantages of air transportation over water as compared with that over land. He gave the record of the Aeromarine airways whose planes traveled one million miles and carried fifteen thousand passengers without mishap. Col. Paul Henderson, Second Assistant Postmaster-General, in speaking of the air mail, called attention to the fact that from July 16, 1921 until September 7, 1922 two million miles were flown without accident; 94.39 per cent of all trips were finished on schedule time. C. G. Peterson presented an analysis of the proposed direct air-mail route between Chicago and New York. William P. McCracken, Jr., Chairman of the Aviation Committee of the American Bar Association, discussed the aeronaut's rights, the aeronaut's liabilities and the extent of the power of government agencies to regulate aeronautics. Edmund Ely, President of the National Aircraft Underwriters Association, told of the studies of aircraft insurance, and Professor E. P. Warner, of Massachusetts Institute of Technology, reviewed the developments of commercial flying in Europe.

Considering the subject of commercial air transport J. R. Bibbins, Manager, Department of Transportation and Communication United States Chamber of Commerce, stated the following important principles as a result of a study by the United States Chamber of Commerce:

> The immediate support of basic national legislation on aeronautics providing for appropriate regulatory procedure.
>
> Such legislation to be broadly conceived, in the nature of an enabling act providing for the adoption, administration, and improvement from time to time of an Aeronautical Code under proper Government authorization created by the Act.
>
> Adequate facilities within the Department of Commerce for promoting the regulation and development of commercial air-transport operations in interstate and foreign commerce.
>
> Intra-state legislation and operations to conform as nearly as possible to the basic Federal legislation, or at least unified State action.
>
> Encouragement of widespread public support of this essential aeronautical legislation.

He then outlined the needs for a great essential ground organization including

> 1—Coöperation of districts and localities in providing properly equipped air harbors and intermediary air lanes, under unified Federal control.
>
> 2—Coöperation of the Government along certain lines of national aerologic and radio-broadcasting service.
>
> 3—Adequate motor collection and delivery system between air ports and the business centers.
>
> 4—Temporary continuance of the valuable pioneer development work of the Air Mail until substantial realization of above essentials permits of private enterprise.

Following the Air Institute meeting, over three hundred delegates representing groups of states divided into districts on the Government national defense basis met for the election of officers and for the consideration of routine business. The following were elected as officers of the National Aeronautical Association:

President, H. E. Coffin, Detroit
Vice-President, B. M. Mulvihill, Pittsburgh
Treasurer, B. F. Castle, New York City
Secretary, J. B. Coleman, Sioux City, Iowa

Governors, S. D. Walden, Detroit; P. H. Adams, Boston; G. L. Cabot, Cambridge, Mass.; D. Larkin, Jr., Buffalo; M. J. Cleary, New York City; L. F. Sevier, Pittsburgh; R. F. Walters, Baltimore; A. S. Fliery, Birmingham, Ala.; F. H. Burgin, Atlanta, Ga.; G. L. Martin, Cleveland; D. M. Outcalt, Cincinnati; C. S. Rieman, Chicago; Ralph Cram, Davenport, Iowa; Howard Wehrle, Kansas City, Mo.; Edgar Tobin, San Antonio, Tex.; William Long, San Antonio, Tex.; P. G. Johnson, Seattle, Wash.; C. H. Messer, Spokane, Wash.

Two of the national airplane races held at Selfridge Field, Mt. Clemens, Mich. during the week, developed features of particular engineering interest. Archibald Black, of the Aeronautic Division, A.S.M.E., whose paper on The Influence of Design on Cost of Operating Airplanes appears on p. 821 of this issue, commented on these races as follows:

> The Curtiss Trophy Race presented the first opportunity of comparing the performance of airplanes equipped with air-cooled engines with similar models equipped with water-cooled engines thus giving some definite data upon a much disputed point in airplane design. The Pulitzer Race brought out some novel and most interesting features of design and was responsible for some new high-speed records.
>
> The effect of great horsepower on speed was slight, the race being determined by resistance almost alone. While this has been generally known for years, it was never so emphatically demonstrated as in this race. For equal weight and wing area, etc., speed may be assumed to vary with the cube root of the horsepower, as is well known. However, in actual designs where landing speeds govern the maximum wing loading, increased horsepower means increased weight and added wing area. This, in turn, further cuts into the gain in speed, making it even less than the formula would promise.

Engineer to Head Canadian National Railway

The recent coming to North America of Sir Henry Worth Thornton is an event of considerable interest to engineers in America as well as in Canada, where he takes up the duties of president of the Canadian National Railways. Sir Henry Thornton is an engineering graduate of the University of Pennsylvania in 1894, and after experience with the Pennsylvania and Long Island Railroads, he left the superintendency of the latter road in April, 1914, to become general manager of the Eastern Railway Company of England. Americans doubtless recall the comments when he took this important executive position with a road that handles an immense passenger traffic, perhaps the largest in the world. During the war he was a member of the managers' committee for all English railways. In 1916, with the rank of Colonel in the Royal Engineers, he handled all inland navigation in France, Egypt and Mesopotamia. In 1917, Sir Henry went to Paris as assistant director-general of railway movements and in 1918 he was made inspector general of transportation on the continent with the rank of Brigadier-General. In 1919 he became a British subject, was knighted and received a number of continental honors, as well as the Distinguished Service Medal of the United States.

American engineers will follow with sympathetic interest his efforts in administering the Canadian National Railways with their severe and involved problems.

Nation-Wide Treatment of Management Problems

Reports From Local Sections Observing Management Week Show Success of Project—Human Element in Industry and Relation of Engineer to Management Featured at Many Meetings

THE SUCCESS of the first attempt to focus the simultaneous attention of the Society on one topic is amply proved by the great interest that has been aroused in Management Week. The period from October 16 to 21, 1922, was set aside for the discussion of problems of management and their relation to the engineer and some thirty sections of the Society, coöperating where possible with local sections of the Society of Industrial Engineers and the Taylor Society, held enthusiastic meetings at which interesting papers were heartily discussed. The success of the project, which was instituted to develop public interest in problems of management, is shown by the large amount of attention given to the meetings throughout the country by the daily press.

For the nation-wide success of the Management Week program a large measure of credit is due the Committee on Assistance to Local Sections, a sub-committee of the Management Division of the A.S.M.E., and especially to its chairman, John Younger, of Cleveland Ohio. At a meeting held in April, 1922, this committee drew up the general plan for the holding of simultaneous management sessions throughout the country, in coöperation with the Local Sections and the members of the Society of Industrial Engineers and the Taylor Society. Their plan was heartily endorsed by the executive Committee of the Management Division and approved by vote of the Council at its meeting on May 9.

As we go to press reports are coming in from the Local Sections which establish the fact that meetings of this character can be successfully conducted. The Executive Committee of the Management Division is preparing a résumé of the material presented which will be given more fully in a following issue of MECHANICAL ENGINEERING.

NEW ENGLAND

New England, in nine splendid meetings, observed Management Week with a thoroughness that deserves particular mention. From reports so far received Boston shows the largest number of organizations participating in the program. The New England Section of the Taylor Society, the Industrial Engineers' Club, the Bureau of Commercial and Industrial Affairs of the Boston Chamber of Commerce, the Associated Industries of Massachusetts, the Massachusetts Bankers' Association, the Boston Association of Stock Exchange Firms, the Department of Engineering Administration of the Massachusetts Institute of Technology, the College of Business of Boston University, and the Graduate School of Business Administration and the Committee on Economic Research of Harvard University were all represented on the general committee in charge of the meeting. The subject was Management as Related to the Business Cycle, and the points covered in the main addresses related to retail merchandising, bank credits, forecasting business conditions, the practical application of cyclical forecasts to manufacturing management, and management and sales policies at the present point in the business cycle. The discussion was particularly good as leaders had been chosen for each paper.

Worcester states that its management meeting was the most successful undertaking of the Worcester Section for many months. It was participated in by the Chamber of Commerce, the Rotary Club and the Kiwanis Club. The subject, What are the Standards by which the Work of a Manager may be Measured? was brought out in three addresses and in the discussion the manager's relation to equipment, business forecasting, and particularly to the men whom he directs, were considered.

Six meetings were held in Connecticut, at several of which L. P. Alford's paper on Ten Years' Progress in Management was read and discussed, being presented in person by Mr. Alford at Meriden. At Bridgeport, where the Steel Treaters' Society of Bridgeport participated, the administrative phase of management was discussed. At Hartford Time Studies as a Basis for Rate Setting and Precision Standardization and Production were the subjects of papers.

The meeting at Providence, not yet reported, dealt with the relation of the bank to the manufacturer.

CENTRAL STATES

The Metropolitan Section, meeting with the local sections of the Society of Industrial Engineers and the Taylor Society, heard and discussed Mr. Alford's paper, presented in person, and papers on management in Great Britain and Germany, written by members of the engineering profession in those respective countries.

The keynote of the Syracuse meeting was coöperation. The Technology Club of Syracuse joined in this meeting and the general discussion kept the human element of the management problem in the foreground.

Buffalo reports lively discussion on the subject of industrial management.

Inspection of the Standard Steel Works and the Susquehanna Silk Mills formed apart of the Management Week program of the Central Pennsylvania Section. Mechanical and industrial engineering students from The Pennsylvania State College and Bucknell University attended the meeting. The application of human relations to every business and training men for leaders were the questions around which discussion centered.

The Plainfield meeting, which was based on Mr. Alford's paper, and other meetings in the Central States have not been fully reported.

IN THE SOUTH

The Birmingham Section held a joint meeting with the Alabama Technical Society and the Engineering Department of the University of Alabama, at which industrial management, business management and present-day business conditions were topics under consideration. New Orleans, meeting with the Louisiana Engineering Society, took up the more specific phase of management, that relating to a ship-repair plant.

MANAGEMENT WEEK IN THE MIDDLE WEST

Judging from the wealth of press clippings on meetings in Chicago, Cleveland, Cincinnati, Columbus, and other cities in the Middle West, Management Week was particularly welcome to the general public as well as to the profession. Cleveland, of course, had the benefit of Mr. Younger's assistance in developing its program. The local sections of both the Society of Industrial Engineers and the Taylor Society joined with the Cleveland Section of the A.S.M.E. in the observance of Management Week, and "What about the Man?" was the dominant thought in all the addresses. Failure to consider the human element in industry was cited as one of the main contributory causes of the nation's industrial difficulties. What management means to the business man and the importance of management from his point of view were vital questions considered.

In Columbus constructive action for the future was taken in the formation of a Management Club affiliated with the Chamber of Commerce to study local management problems and to furnish points of contact with local engineers. The matter of taking up some of the problems of management as a post-graduate course at the Ohio State University was also discussed. Three meetings were held in conjunction, respectively, with the Engineering and Commerce classes of Ohio State University, the Columbus Chamber of Commerce, and the Associated Engineers' Club of Columbus, all of which were well attended.

Chicago also observed Management Week on three different occasions. At the first, a joint meeting with the Chicago Association of Commerce, the subject of the address was Business Conditions Abroad as Reflected in American Prosperity. Fellowship between employer and employee, the practical application of management methods, and management control were problems considered at the other meetings.

Cincinnati, in two joint meetings with the local section of the Society of Industrial Engineers, touched also upon the human-relation element and the relation of the manager to his banker.

Modern production methods, and management with a view to the future, were other questions well discussed.

Another note was struck in an address on Citizenship and the Engineer, by Dexter S. Kimball, President of the Society, before the Indianapolis Section. He pointed out that the scope of the engineers' activities must broaden and that they must now study men according to the same forward-looking methods they have employed in studying machinery and be prepared to solve problems involving human relations in industry.

Standards for measuring the work of a manager or of management, the subject considered at Worcester, was also the topic for discussion at a meeting of the Engineers' Club of Dayton to which a number of A.S.M.E. members belong.

Among the other sections of the Middle West which held meetings were the St. Louis, Toledo (with Rotary Club), and Tri-Cities, where Mr. Alford's paper was presented.

Pacific Coast Meetings

The Western Washington, San Francisco, and Los Angeles Sections held strong meetings in observance of Management Week. Mr. Alford's paper formed the basis of discussion at Seattle and Los Angeles, and engineers in management was the subject of the meeting at San Francisco, which was held in conjuction with the Society of Industrial Engineers. The method of the engineer in solving problems was again emphasized, and engineers were urged to qualify for that wider range of activities lying outside the scope of their immediate professional activities.

Exchange Professors for 1922-1923

Emanuel de Margerie, of the University of Strasbourg, and Dean John Frazer, of the University of Pennsylvania, are the exchange professors between France and America for the academic year 1922–1923. This is the second exchange of professors under the scheme inaugurated last fall between the French University Administration and seven American institutions. Dr. A. E. Kennelly, professor of electrical engineering at Harvard University and the Massachusetts Institute of Technology, and Professor Jacques Cavalier, rector of the University of Toulouse, were the first to serve.

Professor de Margerie, who has begun work at Columbia University, where he is lecturing on applied geology, especially as applied to topography, is widely known through his French translation of Eduard Suess' Das Antlitz der Erde. He has published a large number of works on geological subjects, among which should be named Dislocations of the Earth's Crust, written in conjunction with Prof. Albert Reim, of Zurich, fixing the nomenclature of structural geology in French, English, and German; an account of land forms, prepared in conjunction with General de la Noe, of the geographic service of the army; Catalogue of Geology Bibliographies; and his latest work, a monograph on the structural geology of the Jura Mountains of France and Switzerland, written under the auspices of the French Geological Survey.

Professor de Margerie has been for many years in close touch with numerous American geographers and geologists, his first visit to this country being in 1891. In 1912 he was one of the foreign guests invited by the American Geographic Society to participate in its transcontinental excursion, and wrote a paper in English for the memorial volume giving the history of the trip.

Among his many associations are the following: Director of the Geological Survey of Alsace and Lorraine; chief geologist of the Geological Survey of France; vice-president of the French National Research Council; and associate editor of the *Annales de Geographie;* He is a member of the geographical societies of America, London, Paris and France, all of which have conferred special honors upon him, and general secretary of the International Conference on the Map of the World.

Other institutions at which Professor de Margerie will lecture are Harvard, Cornell, Johns Hopkins, Yale, Massachusetts Institute of Technology, and the University of Pennsylvania.

The exchanging of professors between France and the United States is regarded as an important factor in the movement for closer relations between the engineers of the two countries.

Secretary Rice Returns from South America

Just as this issue of MECHANICAL ENGINEERING went to press, Calvin W. Rice, Secretary of The American Society of Mechanical Engineers, returned from his trip to South America where he represented the A.S.M.E. among other societies at the International Engineering Congress held in conjunction with the Brazilian Centennial Exposition. Speaking informally of his trip Mr. Rice was enthusiastic over the Congress, his courteous and cordial reception everywhere, but particularly over the possibilities of furthering constructive international relations which his trip revealed.

"The resolutions which the International Engineering Congress passed," said Mr. Rice, "were alone sufficient to justify the Congress. They give to engineers of all countries a basis for cooperation and an object of permanent good in each country.

"At the conclusion of the Congress, the United States engineers gave a brilliant banquet at the Jockey Club to the Minister of Public Works, Dr. Pirez do Rio who opened the Congress, the officers of the Congress and of the Club de Engenharia. On account of the magnitude of the engineering construction going on in Brazil the Minister of Public Works is the most important member of the Cabinet. The Club de Engenharia has a most unique position in the nation. Its president, Dr. Frontin, is an engineer of great ability, a kind of popular idol, and a man who has great political power.

"At one of the committee meetings of the United States engineers they pledged themselves to develop a list of all technical words and phrases used in Portuguese, as neither Spain nor Portugal nor any of their colonies has developed a technical vocabulary. A phrase in one city in Brazil often has a different meaning in another city. Vernel L. Havens, as a representative of the McGraw-Hill Book Co., promised to publish the work when completed. Here is a definitely worthwhile job coming out of the Congress.

"In the cities of Santiago, Lima, Montevideo, in fact, everywhere I went, in spite of the briefness of my visit the teamwork was such that there is every reason to believe that engineers in South America are ready to work with engineers of other countries in service to the profession and to the public.

"In every country visited I urged:

1 That every professional man from the United States affiliate with the local engineering society of the country where he is residing, even if only temporarily.
2 That they form within or under the auspices of the local society groups of members of the National Engineering Societies of the United States for purposes of service to the local society.
3 That the local society link up with its government.
4 That the organizations of engineers,—members of U. S. societies—link up—
   a With their country's government through the embassy and commercial attaché and with the Inter-American High Commission.
   b With the National Engineering Societies of the United States.

"The reaction that I get from the entire trip is that throughout the world there is the liveliest pride in one's profession and in his society. In fact, it is an inspiration to try to live up to the standard that members establish. As a society we cannot go on unless it be with a devotion to the public good as our definite aim and purpose."

Mr. Rice is preparing a more complete report of his trip. It will appear in the January issue of MECHANICAL ENGINEERING.

Engineering Foundation Elects Director

The government board of Engineering Foundation, in view of the expanding needs of the organization in its work of industrial search, has created the post of director, to which Alfred D. Flinn, secretary of the Foundation since January, 1918, has been elected. Mr. Flinn will retain his position as secretary of the United Engineering Societies, which he has also held since January, 1918, in order that intimate relations with the Founder societies may continue, but will retire as chairman of the Engineering Division of the National Research Council.

News of The Federated American Engineering Societies

Recent Reports Summarize Services of the Federation to the Nation

TWO recent reports on the work of The Federated American Engineering Societies, one by Edwin S. Carman, chairman of the A.S.M.E. delegates to the American Engineering Council, and the other by L. W. Wallace, executive secretary of the Federation, indicate how well the purpose of the organization, so clearly defined at its organization meetings in 1920, has been achieved. Some seventy delegates, representing over 100,000 engineers, who attended the first meeting, held in June, 1920, were agreed as to the need for some sort of comprehensive organization which (as one editorial stated) "may speak with the authority and prestige of all engineers and groups of engineers, created with the avowed purpose of public service." This sentiment was incorporated in the constitution of the Federation in the words: "Service to others is the expression of the highest motive to which men respond, and duty to contribute to the public welfare demands the best efforts men can put forth, therefore, the object of this organization shall be to further the public welfare wherever technical knowledge and engineering experience are involved, and to consider and act upon matters of common concern to the engineering and allied technical professions."

Among the F.A.E.S. activities on which Mr. Carman reported are the twelve-hour shift in American industry, the elimination of waste in industry, the Nolan Patent Bill, the Muscle Shoals problem, the flood-control research laboratory, and standardization work. Concerning the first of these subjects Mr. Carman said: "The public press has corroborated the belief of the American Engineering Council that the Report of the Twelve-Hour Shift in American Industry is doubtless one of the greatest contributions to the welfare of mankind that has yet been made by the engineer." This report, part of which appeared in the October issue of MECHANICAL ENGINEERING, page 681, was made under the auspices of the Committee on Work Periods in Continuous Industries of the F.A.E.S., and was financed by the Cabot Fund. The subject of frequent comment in the public press, it has done much to educate the public to the fact that the engineer is vitally interested in industry's human as well as its material problems. This report will appear in book form in the near future.

The report of the Committee on the Elimination of Waste in Industry and the passage of the Nolan Patent Bill are two outstanding achievements which have engaged the attention of the F.A.E.S., details concerning which have been so widely circulated in both the secular and the technical press as to require no further explanation.

It is in problems of the Muscle Shoals type, Mr. Carman pointed out, that an organization such as The Federated American Engineering Societies is admirably fitted to render unselfish public service by making available the facts relating to the development at Muscle Shoals.

The bill authorizing the establishment of a Research Laboratory for Flood Control was conceived and is backed by the F.A.E.S. The Federation, coöperating with the Department of Commerce, has brought about a standardization of paving bricks which resulted in the elimination of fifty-five of the sixty-six kinds previously used.

Mr. Carman also stressed the value to the individual engineer of the publicity which the Federation is gaining for the profession, quoting President Cooley, who in a recent address on What the Federation is Doing, stated that before the formation of the Federation, the engineer had no vehicle to convey his knowledge to the public in general and that he was known only by his works. The public thought of him as dealing only with material things, with no particula ability to enter any other field than that of directing and handling the forces and materials of nature, from which a bridge or a machine may result. The problems which the F.A.E.S. has already handled and the problems which are now under consideration, with the publicity given to them, have done much to acquaint the public with the engineer's ability in heretofore unoccupied fields that lie within the scope of his profession.

These and other concrete activities into which the ideals of the F.A.E.S. constitution have materialized were enumerated in Mr. Wallace's report. The Federation has supported various items of Federal legislation, among which may be mentioned, in addition to the National Hydraulic Laboratory, the revision of mining laws, embargo on dyes, reclassification and compensation of engineers in Government service, Federal road act, and topographical survey. It has aided the Postoffice Department in the matter of establishing a materials-handling division, the Civil Service Commission in formulating a salary scale, the Ordnance Department in regard to design of equipment, the Bureau of Forestry in reforestation, and various other departments and bureaus in supplying information of miscellaneous character. Through official representation it has participated in conferences on the reduction of styles and sizes of paving bricks, as previously mentioned; on highway construction, for the consideration of letting of fall highway contracts; on unemployment; and on national jurisdictional awards in the building industry.

While not exhaustive, this summary indicates the scope and character of the work of the Federation. The *public recognition* of the value of its services is a point which should receive particular emphasis in such a summary, for the importance of this factor in the continuing success of the organization is obvious, in that it is essential to an ever-broadening field of service.

Engineers on Coal Commission

Among the appointees to the President's Coal Commission are two engineers, John Hays Hammond and George Otis Smith. This is in accordance with a recommendation of the F.A.E.S. that two engineers be named, and Dr. Smith, who has temporarily resigned as director of the Geological Survey to serve on the Coal Commission, is one of several engineers which the Federation suggested for the place.

Other members of the Commission are Thomas R. Marshall, Samuel Alschuler, Clark Howell, Edward T. Devine, Charles P. Neill, David L. Wing, and C. E. Lesher, who will direct engineering investigations. At its organization meeting Mr. Hammond was elected chairman and Edward E. Hunt, who was a member of the Federation's Committee on the Elimination of Waste, was retained as secretary. The Commission will assemble all the essential facts touching the coal industry, to the end that practical measures may be found to insure a constant supply of coal at as reasonable prices as are consistent with fair wages and profits to those engaged in the industry.

The Promotion of Engineering Research

To establish state engineering experiment stations in the states and territories in connection with institutions of higher technical education for the promotion of engineering and industrial research as a measure of industrial, commercial, military, and naval progress and preparedness in times of peace or war, is the purport of a bill recently introduced in the House of Representatives. According to the provisions of this act such stations would be established under the direction of and in connection with some university, engineering school, or land-grant college, the state legislatures to designate and appoint those institutions best equipped and organized to conduct such researches. The far-reaching benefits to be derived from the experiments and investigations conducted in such stations will be evident to the engineering profession.

Among the subjects in connection with which researches, investigations, and experiments shall be conducted are those relating to transportation, road building, drainage, flood protection, aeronautics, aerodynamics, fuels, power, lighting, heating, refrigeration, ventilation, sanitation, architecture, and war activities.

The responsibility for the initiation and conduct of research shall rest with the individual engineering experiment station, but through the exchange of reports and the assistance of the Department of Commerce care will be taken to secure practical uniformity of methods, efficiency, and economical expenditure of funds, and to avoid useless duplication of research work.

Engineering and Industrial Standardization

The Main Committee of the A.E.S.C. Holds Its Fall Meeting

MANY matters of vital interest were discussed and acted on at the quarterly meeting of this Committee which was held in the Engineering Societies Building on October 19. A morning and afternoon session were necessary to complete the business on the agenda for the meeting. Thirty of the fifty-two members now forming the Committee were present and Mr. Charles D. Young, general supervisor of stores of the Pennsylvania System, Stores Department, Philadelphia, Pa., was announced as the successor to Mr. Alfred W. Gibbs, deceased, one of the representatives of the American Society for Testing Materials.

Mr. S. J. Williams, chairman of the Safety Code Correlating Committee, reported in behalf of his Committee which had held a meeting on the previous day. On recommendation of the S.C.C.C., sponsorship for the Safety Code for Tanneries and the Safety Code for Mechanical Power Control were assigned to the National Bureau of Casualty and Surety Underwriters. The second important recommendation of this Committee was that separating the Safety Code for Exhaust Systems from the Safety Code on Ventilation; both of which subjects had already been assigned to the American Society of Heating and Ventilating Engineers as a sponsor body.

Sheet- and Plate-Metal Working and Forging and Hot Stamping

As a natural development of the work on the recently completed Safety Code for Punch Presses, the Safety Code Correlating Committee now proposes the formulation of safety codes on Sheet- and Plate-Metal Working, and on Forging and Hot Stamping. The American Engineering Standards Committee, while considering favorably this recommendation, referred it back for further consideration and investigation, with the suggestion that possibly the code for forging should be separated from the code for hot stamping.

In accordance with the recommendation of a special committee of which Dr. L. W. Chaney was chairman, the Safety Code for Power Presses submitted by the Sponsor, the National Safety Council, was ordered submitted to letter-ballot of the Main Committee for approval as a Tentative American Standard.

Sponsorships and Personnel Approved

The Code for Electricity Meters having been previously approved as an American Standard, the Main Committee at this meeting designated the Association of Edison Illuminating Companies, the National Electric Light Association, and the Bureau of Standards as joint sponsors for future revisions of the code under the regular procedure of the American Engineering Standards Committee. In the same manner the specification entitled Methods for the Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper was approved as a Tentative American Standard for submission to letter ballot of the entire Committee and the American Society for Testing Materials was designated as Sponsor for this subject.

Votes were taken on the personnel of the following seven Sectional Committees which had been previously circulated to the members of the Main Committee and were all approved as submitted by the Sponsors: Code on Protection against Lightning, Aluminum for Electrical Conducting Purposes, Gas Safety Code, Electrical Installations on Shipboard, Electrical Power Control, Safety Code for Building Exits, and Safety Code for Mechanical Refrigeration.

Legal Penalties Not to be Included in Approved Safety Codes

For some time it has been the opinion both of the men engaged in the formulation of safety codes and of practically all state officials that legal penalties for failure to conform to approved safety codes and methods of enforcement can be worded best by the industrial board of each state as it adopts the standard code.

On the recommendation of the Safety Code Correlating Committee, therefore, the American Engineering Standards Committe has established the policy to exclude from all safety codes developed under its auspices all clauses relating to legal penalties or to methods of enforcement.

Cooperation with the Federal Specifications Board

As chairman of a special committee which had investigated this subject, Mr. A. A. Stevenson outlined the present and proposed relations between the American Engineering Standards Committee and this Board. He stated that the purpose of the Federal Specifications Board is to unify Government specifications, and to bring them into line with the best commercial practice. Before adoption by the Board the proposed specifications are being submitted to the American Engineering Standards Committee, at first informally, to determine their acceptability to industry, and for criticism. It was hoped that in future revisions many if not most of them would go through the regular American Engineering Standards Committee procedure. The special committee felt that the action of the Federal Specifications Board presented an opportunity to the A.E.S.C. to render a notable service both to the Government and to industry, and that a forward step in national industrial standardization should result.

Seven specifications have already been submitted. These are: Hose Specifications, Specifications for Wood Screws, Specifications for Sterilizing Equipment, Specifications for Numbered Cotton Duck, Specifications for Pig Lead, Specifications for Silicon Copper, and Specifications for Phosphor Tin. These are being handled informally, by committees organized somewhat upon the lines of those handling projects submitted for approval under Section R-4 of the Rules of Procedure.

The recommendations of the special committee were discussed at length. After a detailed consideration of each of the recommendations of the committee, and upon motion by Mr. A. A. Stevenson, the following action was taken by unanimous vote:

In order to assist the Federal Specifications Board in bringing the Government specifications into line with the best commercial practice be it—

Resolved, That the American Engineering Standards Committee will use its facilities and its contacts to obtain for the Federal Specifications Board the reaction of industry to the various specifications which may be submitted;

Resolved, That this be done through the organizations which speak for the branch of industry concerned in any particular specifications, and through outstanding individuals;

Resolved, That the work be carried out under the general direction of a small committee advisory to the Chairman of the American Engineering Standards Committee;

Resolved, That all of the detailed work on each specification be done informally and with such minimum machinery as may be determined by the aforesaid committee in each case;

Resolved, That the American Engineering Standards Committee will not concern itself with the details of any of the specifications.

It was agreed that the special committee should be discharged and that the work on specifications to be submitted by the Federal Specifications Board hereafter should go forward under the general direction of the small committee provided for in the Reso'utions which are to be appointed by the Chairman.

A.E.S.C. Handling 106 Projects

Of the projects which have official status before the A.E.S.C., 20 are concerned with mechanical engineering; 17 are civil engineering projects; 15 are electrical; 3 are automotive; 10 are concerned with transportation; 10 with ferrous metals; 11 with chemical; 5 with non-ferrous metals; 4 with mining; 2 with textiles; 1 with shipbuilding; and 8 projects are of general interest.

Twenty-four standards or safety codes have been approved and 36 are up for approval. The remaining 46 projects represent codes and standards which are either in the process of formulation, or which are now being considered by committees of representatives, designated by the various bodies, industrial technical and governmental, interested in each particular subject. In this way more than 200 such bodies are officially participating in the work of the A.E.S.C. through their accredited representatives.

A regular interchange of information as to the status of work under way is maintained by the American Engineering Standards Committee with the national standardizing bodies of Austria, Belgium, Canada, Czechoslovakia, France, Germany, Great Britain, Holland, Italy, Japan, Sweden, and Switzerland. This information is issued in the form of quarterly reports and includes a statement of the status of each project on which work is actively under way.

THIRTEEN SPECIFICATIONS SUBMITTED UNDER RULE R-4

The American Society for Testing Materials submitted to the A.E.S.C. in due form its specifications on the subjects which are listed below.

Specifications for Carbon-Steel and Alloy-Steel. Blooms, Billets and Slabs for Forgings (A17–21)
Specifications for Cold-Rolled Steel Axles (A22–21)
Specifications for Carbon-Steel Bar for Railway Springs (A14–16)
Specifications for Helical Steel Springs for Railways (A61–16)
Specifications for Elliptical Steel Springs for Railways (A62–16)
Specifications for Welded and Seamless Steel Pipe (A53–21)
Specifications for Welded Wrought-Iron Pipe (A72–21)
Specifications for Refined Wrought-Iron Bars (A41–18)
Specifications for Wrought-Iron Plates (A42–18)
Specifications for Staybolt, Engine Bolt and Extra Refined Wrought-Iron Bars (A84–21)
Method of Test for Unit Weight of Aggregate for Concrete (C29–21)
Method of Test for Voids in Fine Aggregate for Concrete (A30–22)
Method of Test for Organic Impurities in Sands for Concrete (C40–22)

These proposals are now before the members of the American Engineering Standards Committee, and Dr. P. G. Agnew, Secretary of the Committee, will be glad to receive as much information as possible concerning the use and general approval of these thirteen standards.

Conference on Numbering of Steel Called by A.E.S.C.

A conference to consider the desirability of providing a system of designating qualities or kinds of steels by code numbers, has been called by the American Engineering Standards Committee at the request of the U. S. Bureau of Standards. The conference will be held in Room 704, Department of Commerce Building, Nineteenth Street and Pennsylvania Avenue, Washington, D. C., at 10 a.m., December 6.

The subject of this conference is a matter of great importance to all manufacturers of steel and to all users of steel in large quantities. This conference will attempt to determine the desirability of applying a uniform numbering system to forging steels, casting steels, structural steels, including plates, tool steels or other steels not so classified.

While the American Engineering Standards Committee has invited to this conference representatives of all technical and industrial associations known to be interested in the subject, any organization which feels that it should be represented in the conference, but has received no formal invitation, is urged to communicate with the American Engineering Standards Committee, 29 West 39th Street, New York City.

The Society of Automotive Engineers has already formulated a system now in wide use, applying to the steels used in automotive practice, and there has been considerable discussion as to the advisability of applying such a system more generally.

The following are the agenda which were suggested for this conference, at an informal meeting in New York on September 15, 1922, of persons interested in the topic:

1 Address by W. A. Durgin, Chief, Division of Simplified Practice, Department of Commerce, Washington, D. C.
2 Election of Chairman, Alternate and Secretary.
3 Résumé of present American Practice and of the steps leading to the conference.
4 Résumé of European practice by L. H. Fry.
5 Is it desirable to have a uniform numbering system for forging steels?
6 Is it desirable to have a uniform numbering system for casting steels?
7 Is it desirable to have a uniform numbering system for structural steels, including plates?
8 Is it desirable to have a uniform numbering system for tool steels?
9 Is it desirable to have a uniform numbering system for any other steels?
10 What should be the basis of classification for such a numbering system: chemical composition, physical properties, or heat treatment?
11 Are there systems existing which can be used as a basis for any or all of the above groups?
12 What, if any, are the limitations of systems now in use or proposed?
13 Are there special steels that will not fit a numbering system?
14 Can a system be worked out to permit of varying tolerances?
15 Can brand names be accommodated to and associated with a numbering system?
16 Are there other recommendations that the conference wishes to make to a continuing or sectional committee?

Standardization of Shafting

Through its chairman, Prof. A. H. Beyer, the Sub-Committee of this Sectional Committee which is standardizing the technique of shafting design has reported the completion of Part 1 of its report. As outlined below, this part is a highly technical discussion of the theory involved in this project. Owing to this fact it has not been deemed advisable to manifold this analysis, but typewritten copies are available for loan to those persons especially interested.

Part 1—The Application and Limitation of Shafting Formulas. This is a résumé of the many formulas heretofore advanced, with special emphasis on their proper application to the design of shafts under various conditions of loading to which a shaft may be subjected. The application and limitations of these formulas are discussed in detail from the standpoint of the many theories of elastic failure advanced from time to time for material under combined stress. The report concludes that under complex stress distribution the maximum intensity of the shear stress is the factor which ultimately determines elastic failure. As a result, comparatively simple formulas based upon the maximum shear theory of elastic failure are recommended as standard.

Part 2—Technique of Shafting Design. The second part of the Sub-Committee's report now in preparation will set forth in detail in accordance with the conclusions set forth in Part 1 the formulas recommended as standard for the design of shaft under the varying loading conditions. Definite unit working stresses for the different shafting steels will be recommended, and as far as possible the technique of shafting design will be standardized.

John Bergoyne Foote Dies

In the death of John B. Foote on October 12, 1922, the gear-manufacturing profession lost one of its most active members. Beginning at the age of fourteen as die setter for the Chicago Stamping Co., he had advanced step by step to the office of presidency of the Foote Brothers Gear & Machine Co., Chicago, and had become in that time thoroughly familiar with all branches of his profession.

Mr. Foote took a keen interest in anything that would further efficiency in machine operation. He was a pioneer in making cut-steel, case-hardened, tough-cored gears for heavy-duty work. He was one of the first to invent and build enclosed types of transmission for reducing electric-motor speeds and in connection with the development of the present light-weight type of farm tractor was the inventor of the enclosed transmission and live-axle drive. He also invented numerous automatic machines for making cans and was regarded as a foremost authority on special machinery.

In addition to his position as president and treasurer of the Foote Company, he was also a director of the Barton Spider Web Reenforced Concrete System; president and director of the Illinois Tractor Co.; treasurer of the American Tractor Association; director of the American Gear Manufacturers' Association; and a member of the Society of Automotive Engineers and various fraternal and athletic clubs.

NEWS OF OTHER SOCIETIES

SOCIETY OF INDUSTRIAL ENGINEERS

The theme of the ninth national convention of the Society of Industrial Engineers held in New York, October 18, 19, and 20, 1922, was Economics in Industry, and the program was devoted to the study of the fundamentals necessary to obtain maximum production with minimum effort, waste, and cost. Among the specific subjects were economics in the formation of a policy of business administration, the economic background necessary for a business executive, the relation of fatigue elimination to other activities, the budget and the financial forecast, the importance of the elimination of waste to the economic structure, reduction of production costs, keeping workers contented, industrial accounting, reducing sales costs, scientific selection of people for jobs, and materials handling.

Prof. Joseph W. Roe, president of the society and head of the Department of Industrial Engineering at New York University opened the convention with an address on the relation of economics to industry. The economist, he said, is essential to all large-scale industry. He collects and studies masses of facts covering wide areas and long periods of time and understands and can deal with forces of which the manager is conscious but with which he is not trained to cope. In the case of wages, for instance, studies covering nominal and real wages in all the major industries and in all countries, back to the Middle Ages, the trend of prices and the history and causes of periodic fluctuations, enable the economist to meet intelligently the conditions surrounding each recurrent cycle. Professor Roe advocated more general reading on economics, industrial history, and labor relations by industrial executives and labor leaders, the introduction of courses on these subjects in colleges and schools, and the development of a systematic study of the sources, quantities, and prices of industrial materials and the means of making such information more generally available.

Discussing the part of economics in the formation of a policy of business administration, J. H. Pardee, president of the J. G. White Management Corpn., New York City, pointed out that in fixing the relation of selling price to production costs, the rate at which the public will buy must be carefully considered, and emphasized the need of common units and methods of measurements. The development of rational standards in regard to the latter he believed to be a big opportunity for service.

The education group of the society took up the question of the economic backgound necessary for a business executive. Among the speakers were Dr. Lee Galloway, Ronald Press, New York, Prof. F. D. Fairchild, Department of Social and Political Science, Yale University, and Prof. E. H. Schell, Department of Economics, Massachusetts Institute of Technology, who described the aims and methods of training administrative engineers in that institution.

A new and inexpensive device designed by Dr. Frank B. Gilbreth, Montclair, N. J., to eliminate fatigue in the transference of skill or in studying methods of performing work, was described by him. By means of this, details of the methods of an expert worker can be studied from moving-picture photographic prints in a leisurely manner without personal contact. Among the speakers on the subject of the relation of fatigue elimination to other activities were Dr. L. I. Harris, Department of Health, New York City, Prof. K. Spooner, Polytechnic Institute of London, and Dr. Uyeno, University of Tokio.

R. B. Wolf, consulting engineer, New York, and vice-president A.S.M.E., emphasized the need for a budget for the workman in an address on the importance of the elimination of waste to the economic structure. He defined waste as essentially the time which has passed when constructive thinking was absent, to reduce which the creativeness of the worker must be stimulated. Comparative performances enable the worker to see the possibilities of the future, and production cost records will help him to understand his relations to his fellow-workmen and to the plant as a whole.

Sherman Rogers, speaking on Short Cuts to Industrial Sanity, agreed with this policy, stating that no workingman will make a one hundred per cent effort until he understands the rules of the game he is working under.

A session was devoted to discussing how to reduce production costs and how to keep workers contented. J. A. Faust, Waltham Watch Co., Waltham, Mass., presented the executive viewpoint on the first of these questions. The executive, he pointed out, must have the ability properly to conduct financing, production, and sales. He took up the specific problems of reducing inventories, decreasing turnover, establishing best production methods, reducing the line of products, and compensating labor so as to secure the best returns. The worker's viewpoint was presented by William Geiger, Keratol Co., Newark, N. J. He advocated the better use of the worker's time and skill and a fifty-fifty basis for both work and pay, and commended the piece-work plan as easy to understand and practical to use if the operation is repeated. Charles Cheney, Cheney Brothers, South Manchester, Conn., believes in the efficiency of the credit-rating plan for keeping workers contented. This provides for putting the worker into a grade or class in which the base rate has been fixed, and adding to this rate for qualities which render him especially valuable as an employee, such as a record for quality and quantity of production, length of service, record of attendance, versatility, etc.

The industrial relations division of the society held a meeting, the subject of which was how to develop a more scientific method of selecting people for jobs. Earl B. Morgan, manager of employment and service, Curtis Publishing Co., Philadelphia, emphasized the importance of a pleasant stage setting for interviewing employees, the superiority of practical tests over written examinations, and the fairness of competition for employees as well as for business. Discussion at this meeting brought out the value of analyzing the characteristics of both executives and employees so that they may be fitted into the places where they work together to the best advantage and the most harmonious relations may be maintained. The foreman's part in selecting and dismissing employees was also discussed.

Ernest F. Du Brul, general manager of the National Machine Tool Builders' Association, made some pointed remarks concerning the economic aspects of production. In economics, he said, production means, not the fabrication of physical goods, but the creation of utility, whether of time or place or form, and presupposes adequate demand. Production, if increased beyond the point where a use or a profitable market can be found for the goods, is wasted effort and capital. Mere fabrication does not necessarily create value, for the price obtained for the goods is measured by the value to the buyer at the time of sale, not the cost to the producer. If the manufacturer does not rightly forecast the demand at the time of manufacture and adjust the supply to meet it, he must sell at a loss. It is also true that greater output may not mean lower cost and greater profit. Mr. Du Brul commended the man who takes business risks for the sake of the world's progress.

The final session of the convention was on the subject of materials handling. The special phase considered was the application of economics to materials handling for the purpose of reducing cost and increasing production. R. A. Wentworth, manufacturing manager of Barrett Co., New York, spoke on the shortage of man power since the war, and pointed out the opportunities for service in developing machinery for materials handling. M. R. Dennison, superintendent of the stores division of the Studebaker Corpn., described some of the crane equipment and special hoisting devices in use at the South Bend works of his company. Hand labor has been practically eliminated in this plant, especially in the handling of waste material, which is one phase of material handling usually overlooked. In the South Bend plant a tunnel equipped with a conveyor receives the borings and turnings which are delivered to trucks. One tractor is devoted to this use and cranes are used to place the boxes in the cars.

M. W. Potts, construction engineer, presented a paper on portable elevators or tiering machines, and showed motion pictures of the process of the handling of dies from storage to the punch presses and the handling of tote boxes at the plant of the Seng Co., Chicago. The loading of wire on cars at the works of the Interstate Iron & Steel Co. was also shown, this installation being said to have reduced the time of loading a car from two and one-half hours to one hour.

An illustrated talk on the use of steel belt conveyors was given by Harry Carlson, Sandvik Steel, Inc., New York, in which he

outlined the ease of installation, the rust-resisting properties of the belt, and the simplicity with which material can be discharged at any point along the conveyor without the use of expensive trippers. The speed of the steel belt varies from 135 to 300 ft. per min., the average being 200 ft.

The final address on the program was made by W. P. Stivey, Philadelphia, who discussed the design and use of gravity conveyors. Mr. Stiver emphasized the need for selecting machines suitable for the work they have to perform, such as using light units for light work. Mr. Stiver advocated the use of more boosters than are usually found, and explained the principle underlying the action of helical chutes. In conclusion, he gave eight principles underlying the successful installation of gravity conveyors. The use of conveyors requires a knowledge of various types of equipment available so that the one best adapted to the particular use may be selected. Routing conditions must also be studied and the layout for the conveyors considered when the buildings are being planned. The use of the equipment should be thoroughly understood and some one person should be responsible for keeping it in condition.

In connection with the convention an exhibition of various products, particularly materials-handling equipment, was held. A miniature model of a conveyor system made up of a helical chute, belt and gravity conveyors, inclined-slat conveyor and an automatic straight-lift elevator, was displayed by the Standard Conveyor Co., of North St. Paul, Minn. The Lamson Co., of Boston, showed patented differential curve and various pneumatic-tube carriers used in connection with its conveyor. Sandvik Steel, Inc., New York, exhibited a model of an actual installation of a steel-belt conveyor, with all units one-twentieth actual size, and combining inclined and horizontal drive in one unit. A portable scoop conveyor was shown in operation by the Portable Machinery Co., Passaic, N. J., a telescoping portable elevator was demonstrated by the Economy Engineering Co., Chicago, and a large exhibit of scales of various kinds was displayed by the Toledo Scale Co. Among other exhibits were industrial systems for inventories, production and machine control, and signal and telephone systems for shop use.

Joint Meeting of Steel Treaters and Forgers

The joint convention of the American Society for Steel Treating, the American Drop Forging Institute, and the Drop Forge Supply Association, held in Detroit, Mich., together with an international steel exposition, during the week of October 2, 1922, eclipsed all previous conventions of this nature, both in attendance and scope. The total attendance was estimated at 18,000. The exhibition and the entertainment and social features of the convention were participated in jointly by the steel treaters and forgers, but the technical sessions, with one exception, were held separately. The program of the American Society for Steel Treating included only about one-third as many papers as have been presented at former meetings, so that there was ample time for discussions. There were sessions on carburizing, heat treating, and tool steel, symposiums on metallurgical education, hardness testing, and research, and three round-table discussions on the subject of heat treating.

The opening technical session included three papers on carburizing. H. B. Knowlton, Milwaukee Vocational School, discussed carburizing and decarburizing factors determining the success or failure of the case-hardening methods used in commercial practice. The temperature of the lining of the furnace and the ratio of the weight of the charge to the weight of the lining, he said, were important factors in determining the speed of heating. The carbon content of the case was treated in some detail. Irregularities in case-hardening were summarized in a paper by E. W. Ehn, metallurgist, Timken Roller Bearing Co., Canton, Ohio, who said that many failures, especially in reference to soft spots, are due to abnormal steel. Carefully made and deoxidized steel is essential to successful results. A. H. d'Arcambal, metallurgist, Pratt & Whitney Co., Hartford, Conn., described tests on low-carbon steel treated with cyanide. Due to its lower hardness, plain carbon steel will show a higher impact reading than an alloy steel.

In a general session on heat-treating problems held October 4, heat treating in lead, furnace atmospheres and scale, electric furnaces for steel treating and chrome-vanadium steels were discussed. R. B. Schenck, metallurgist, Buick Motor Car Co., presented a paper on the first of these subjects in which he stated that the lead pot can produce better work than any other form of heating unit and gave reasons therefor. A paper by G. C. McCormick, assistant metallurgist, Crompton & Knowles Loom Works, Worcester, Mass., presented experimental data from which it was concluded that under certain conditions oxidizing, neutral and reducing atmospheres permit the formation of scale in furnaces. The advantages of electric furnaces for steel treating were enumerated by C. L. Ipsen, designing engineer, Industrial Heating Department, General Electric Co., who also showed lantern slides illustrating various types of furnaces.

Among the papers presented at the tool-steel session was one entitled Lathe Breakdown Tests of Some Modern High-Speed Tool Steels, by H. J. French, physicist, U. S. Bureau of Standards, and Jerome Strauss, chief chemist, U. S. Naval Gun Factory. Mr. French classified the steels tested according to chemical composition and used this classification as a basis in discussing the results obtained and conclusions drawn. The effect of structure upon the machining of tool steel was described by J. V. Emmons, metallurgist, Cleveland Twist Drill Co., who stated that conclusions drawn from a period of observation covering five years had been confirmed by successful application to commercial work during the last seven years. A knowledge of the structure the speaker held to be as important as a knowledge of the hardness. Various machining operations were considered and general conclusions made as to the most favorable structure for each.

The hardness-testing symposium was held under the direction of the hardness testing committee of the National Research Council and included an interesting paper on methods of hardness testing at present in use. Pertinent suggestions as to metallurgical education and research in relation to executives, engineering societies, and the Government were made at other symposiums.

A joint session of the American Society for Steel Treating and the American Drop Forging Institute was held October 4, and included addresses on labor matters and anti-trust laws. Employee-representation plans were advocated as one of the fundamentals of successful coöperation which will not be to the detriment of individualism. Other papers at sessions of the Forging Institute dealt with power-plant costs and the flow of metals in forgings.

The steel exposition covering over 50,000 ft. of floor space in the General Motors Building, showed heat-treating equipment and processes of over 100 exhibitors. Machinery and steel company exhibits were numerous, as were also types of furnaces. Pyrometers and other testing apparatus, temperature-measuring apparatus, heat-resisting alloys, refractory and insulating products, forgings of all kinds, and many manufactured products involving heat treatment, made this exposition one of the most impressive ever held.

Inspection trips were made during the week to various motor-car plants in Detroit and vicinity, the Burroughs Adding Machine Company, the Central Forge & Gear Co., the Detroit Steel Products Co., and the Detroit Twist Drill Co.

American Gear Manufacturers' Association

The semi-annual meeting of the American Gear Manufacturers' Association held at Chicago, October 9 to 11, 1922, featured standardization work. Reports and recommendations of its sectional and sub-committees showed splendid progress in this work. The A.G.M.A. sectional committee of the American Engineering Standards Committee reported the status of work on its standard for composite gearing, and its recommended practices for the inspection of gears, for herringbone gears, and for industrial spur gears. A number of other standards affecting the gear industry have been printed[1] and submitted to the sponsor societies for their approval.

The report on straight and bevel gears received particular attention. The basis of the bevel-gear system recommended by the committee is the use of the lowest pressure angle possible without sacrificing strength by introducing excessive under-cut. It was stated that bevel gears cut with a lower pressure angle will operate with less noise than those with a higher angle, other conditions being the same. The system, which applies only to generated gears, pro-

[1] MECHANICAL ENGINEERING, May, 1922, p. 332.

vides three pressure angles, of 14½, 17½, and 20 deg., respectively, for straight-tooth gears in all ratios having ten or more teeth in the pinion. The gear addendum decreases and the pinion addendum increases as the ratios of the numbers of teeth in the gear and pinion become greater.

The report of the metallurgical committee covered recommended practice for carburizing and case-hardening, and for the heat treatment of A.G.M.A. carbon and alloy steels. The inspection committee presented a report on methods of inspecting gears, the use of testing machines, etc., and the nomenclature committee reported that it was assembling nomenclature and symbols in collaboration with other sub-committees.

The measurement of gear noises was the subject of an interesting paper presented by Prof. D. L. Rich, dean of the Department of Physics, University of Michigan. He suggested three methods for the control of gear sounds, namely, absorption of the noise, insulation, prevention.

The question of costs was considered in the report of the cost accounting committee and in that of the commercial standardization committee, the latter stating that the scope of its work is limited because certain commercial practices cannot legally be standardized.

The report of the industrial relations committee disclosed a great variance in the wages of men on the same work in different cities, and discussed the need for a practical system for training apprentices. The latter subject was also taken up in an address by P. C. Molter, superintendent of the department of industrial education, National Metal Trades Association, who outlined a plan worked out by his association which provides a curriculum, fixes rates of pay, holds periodical examinations, and issues certificates. The question of holding apprentices to their contracts was discussed in some detail. Mr. Molter suggested two methods for doing this, one that of supplying the apprentice with tools as he progresses, so that at the termination of his course he will be in possession of a complete kit, and the other that of giving him a bonus at the completion of the apprenticeship term.

T. W. Owen was elected secretary to succeed F. D. Hamlin. His office will be in Cleveland and he will devote his entire time to the association.

American Society of Civil Engineers

San Francisco was also headquarters for the fall meeting of the American Society of Civil Engineers, held October 4 to 8, 1922. The subject under consideration was the water-power problem, and the program included several strong sessions at which technical papers were presented, local excursions, and a two-day trip to the Hetch Hetchy project.

John A. Britton, vice-president and general manager of the Pacific Gas & Electric Co., San Francisco, delivered the address of welcome, to which John R. Freeman, president of the society, replied. Mr. Freeman compared the modern hydroelectric practice with early developments, describing the Pit River plant in northern California, in which one of the 40,000-hp. units develops more power than the combined output of the 150 installations operating in the vicinity of Lowell and Lawrence, Mass., fifty years ago.

Possibilities in the way of power development in the West were pointed out by several speakers. Arthur P. Davis, director of the U. S. Reclamation Service, in an illustrated talk on the Colorado River development, stated that this is a national problem, involving international rights and with a potential supply of 6,000,000 hp. The best location for a storage reservoir, he said, is the Granite Gorge of Boulder Canyon, which is within transmission distance of large power markets. A reservoir in this gorge would completely eliminate the flood menace of the river and would furnish the regulation and head necessary for a development of 600,000 primary horsepower and fulfill the requirements of irrigation in Arizona and California.

F. H. Fowler, district engineer, U. S. Forest Service, San Francisco, speaking of the water-power potentialities of the Pacific Coast, showed that practically all the western coast is within a 500-mile radius of the two great sources of power, the Colorado and Columbia Rivers.

J. D. Galloway, consulting engineer, San Francisco, stressed the importance of providing for both irrigation and power. The demand for power in California, he stated, has been increasing three or four times as fast as the population, there having been an increase of 138 per cent in nine years. He estimated that the annual energy output will exceed ten billion kilowatt-hours by 1930.

H. W. Dennis and H. A. Barre, both of the Southern California Edison Co., presented a paper telling of the increased services of this company in recent years and plans for future growth.

Among other papers presented was one by F. W. Peek, Jr., consulting engineer for the General Electric Co., Pittsfield, Mass., in which it was stated that the ultimate voltage of transmission would be limited only by sources and markets for power, the cost of high-voltage lines being so great that they can be built only when large amounts of power are to be transmitted.

The social and economic aspects of hydroelectric power production were presented in an address by C. D. Marx, professor of civil engineering, Leland Stanford Jr. University, and past-president of the American Society of Civil Engineers, at an evening meeting on October 5.

The excursion to the Hetch Hetchy project, with a side trip to the Don Pedro Dam, afforded the engineers a splendid opportunity to study the 18-mile tunnel, the concrete and earthen dam, the Moccasin Creek power-house and other units now under construction.

American Iron and Steel Institute

The twenty-second general meeting of the American Iron and Steel Institute was held in New York, October 27, 1922. The general sentiment of the meeting, as expressed by President Gary in his opening address, was that there are no obstacles to continued prosperity in the iron and steel business of the United States except such as may arise from interference with the natural course of supply and demand.

Admiral Vogelgesang, in a dinner address, told of the relation of the navy to the general economic life and particularly to the steel industry of the country.

Nine technical papers were presented, covering the principal activities of the industry. H. Foster Bain, director of the Bureau of Mines, discussed modern methods of mining coal, and showed the Bureau's reel on The Story of Coal, which portrays the operation of mining, both above and below ground. Dr. John A. Mathews, president of the Crucible Steel Company of America, read a paper entitled the Present Status of the Electric Furnace in Refining Iron and Steel, which gave reasons for worldwide expansion of the use of the electric furnace, particularly its versatility and the importance of clean steel.

The economic importance of the power plant in the steel industry was discussed by Edward F. Entwisle, assistant general manager of the Steelton plant of the Bethlehem Steel Co. He pointed out that in many cases the development of the plant's own power supply has not kept pace with the peak power demand, so that electric current frequently must be purchased. He also emphasized the importance in steel manufacture of knowing the cost of every item, raw materials, labor, repairs, transportation, etc., and their relation to each other.

W. P. Chandler, Jr., fuel and experimental engineer for the Carnegie Steel Co., at Duquesne, Pa., in an address on Heating Furnaces for Blooms, Slabs and Billets, described the continuous recuperative furnace and the non-continuous regenerative furnace, pointing out their respective merits, and discussed various methods of firing metallurgical heating furnaces.

The Thermal Efficiency of the Open-Hearth Furnace was the subject of a paper by C. L. Kinney, Jr., and G. R. McDermott, both of the Illinois Steel Co. This paper dealt with the design of a proposed 100-ton open-hearth furnace.

Henry T. Chandler, metallurgist for C. H. Wills & Co., Marysville, Mich., enumerated the steel requirements of the automotive industry, classifying steels as they are used in various parts of motor cars.

A joint paper by John V. Freeman, U. S. Steel Corpn., and Harry H. Stoek, professor in mining engineering at the University of Illinois, dealt with the precautions which are necessary in the piling and draining of bituminous coal and with other factors essential to its safe storage.

Other papers presented at the technical sessions were Fluorspar and Its Uses, by G. H. Jones, president of the Hillside Fluorspar Mines, Chicago, and The Use of Liquid Fuel in Metallurgical Furnaces, by R. C. Helm, director of the Worcester Research Laboratory of the American Steel and Wire Co.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

The 126th meeting of the American Institute of Mining and Metallurgical Engineers was held in San Francisco, September 25 to 29, 1922. The technical sessions were confined to the first day of the meeting and the interest centered about ore-hunting geology and modern ore-dressing methods. At the mining geology session Wilbur H. Grant described the United Comstock mines which he said had produced 3,000,000 tons of ore and $100,000,000 in precious metals. These mines were visited by some 250 engineers on their way to the convention and the paper concerning them was discussed with much interest. The Aztec mine was also described in a paper presented at this session.

At the mining methods session the underground system of handling ore was outlined in a paper by John R. Reigart, superintendent of mines at the United Comstock Mines Co., and a paper on Metal Mine Ventilation in the Southwest was presented by Chas. A. Mitke, of Bisbee, Ariz.

The milling session included two papers on milling methods and metallurgy at the Comstock mines, paper on the mathematical study of basic principles of gravity concentration, and one on research on phenomena in flotation in which surface tension and adsorption play the principal parts.

On Tuesday, September 26, a number of engineers left for the Hetch Hetchy Valley, where the dam which will hold water sufficient to furnish San Francisco and neighboring cities with 400,000,000 gal. daily is partly built. The engineers also visited the lowest power house, at Rattlesnake Creek, where a reservoir is being constructed which will hold a two days' supply of water, the upper power house at the intake of the 18-mile tunnel which will carry the water down from the mountains, Big Creek shaft, an intermediate point on the tunnel line, from the bottom of which the tunnel has been driven over a mile both north and south, and Mather, where the lumber which is being used in the project is being sawed.

There were also excursions during the week to the University of California and Leland Stanford, Jr. University, and an inspection of modern methods employed in the silver refinery at the Selby smelter.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION

Marking the completion of its twentieth year as an organization the National Machine Tool Builders' Association held an unusually strong annual meeting at Lenox, Mass., October 3 to 5, 1922. The retiring president, A. H. Tuechter, president of the Cincinnati Bickford Tool Co., reviewed the work of the association, discussing the problems which it has met and indicating future policies which it should follow in order to be most influential in developing industrial stability. Mr. Tuechter gave considerable attention to cost systems, discussing in particular the cost of unavoidable idleness in the machine-tool industry, and said that one of the most constructive pieces of work that a trade association may undertake is the exposure and elimination of trade abuses.

E. J. Kearney, secretary of the Kearney & Trecker Co., Milwaukee, Wis., was elected president to succeed Mr. Tuechter, and Ernest F. Du Brul, of Cincinnati, was reelected secretary and general manager.

The feature which contributed in a large measure to the success and value of the meeting was the large number of round-table discussions. The topics considered were wide in scope, including thirteen administrative subjects, five technical subjects, thirty sales subjects, and four dealer problems. These discussions formed the major part of the program. Among the few papers which were presented at the meeting was one on the worth of patents to the machine-tool industry, by Joseph K. Schofield, chief of patent department, Niles-Bement-Pond Co., and one on conditions that create unprofitable prices, by O. B. Iles, president of the International Machine Tool Co.

The Institute of Economics

The Carnegie Corporation of New York, in founding the Institute of Economics in Washington, has established another agency for the elimination of waste. The announcement of its formation states that the Institute will endeavor to ascertain the causes of avoidable economic losses and to point the way to their elimination. It will assemble and interpret the economic data which form the bases of national and international policies and present them in as untechnical a form as possible, through books, pamphlets, and special articles. Among the subjects which will receive the attention of the Institute are: international policies; questions of domestic and international finance; the relations of government to business; problems of agriculture, taxation, and transportation; and the various issues relating to industry and labor.

Noted English Engineer Visits United States

William Henry Patchell, vice-president of the Institution of Mechanical Engineers of England and widely known in the central-station field, has been a recent visitor to this country. Mr. Patchell is particularly noted for the design and construction, some seventeen years ago, of the large boiler with 20,000 sq. ft. of heating surface for the Bow Street Station in London. This boiler established a new standard and marked the starting point of modern large boiler practice. Mr. Patchell's experience has extended beyond power-plant work however, and his visit has afforded a remarkable opportunity for American engineers to exchange news on a great variety of engineering subjects.

At a recent dinner given in his honor by a group of central-station designing and operating engineers and executives, Mr. Patchell emphasized the importance of international understanding and coöperation between individual engineers and also between engineering organizations.

He told of the steps being taken in Great Britain where a Joint Council has been formed with representation of the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Naval Architects and the Institution of Electrical Engineers. Mr. Patchell spoke particularly of the A.S.M.E. Boiler Test Code and stated that a joint code was being developed in Great Britain to supersede the old code of the Civil Engineers. He expressed the hope that work on the American code would permit consideration of an international code. In speaking of engineering society activities in England, Mr. Patchell emphasized the importance of the steps taken by the English engineering societies to maintain a high standard of membership qualifications.

First Pan-Pacific Commercial Conference Held in Honolulu

The Pan-Pacific Union, which is "an organization directed by representatives of all Pacific races, supported in part by government appropriation, coöperating with chambers of commerce, boards of education, and kindred bodies in working for the advancement of Pacific interests, bringing together leaders in all lines of thought and action in Pacific lands, and organizing them into friendly coöperative effort," sponsored the first Pan-Pacific Commercial Conference, held at Honolulu, Hawaii, October 25 to 31, inclusive.

The conference was opened with papers indicating the significant Pan-Pacific commercial problems of each country. The general topics for discussion were communication and transportation, development and conservation of natural resources, finance and investments, and international relations in the Pan-Pacific area.

Participation in this conference was especially urged by the press of the Orient, where the work of the Pan-Pacific Union in directing scientific, educational, and press conferences has met with great appreciation. Pan-Pacific associations are among the most progressive organizations in Shanghai and Tokio, and the Union has branches in a number of the cities of the Orient.

The engineers of the United States were represented at the conference by J. A. Steinmetz, a member of the firm of Janney, Steinmetz & Co., of Philadelphia, and by the delegate of The Federated American Engineering Societies. The American Society of Mechanical Engineers was officially represented by S. N. Castle, consulting engineer, of New York and Honolulu.

LIBRARY NOTES AND BOOK REVIEWS

AIRCRAFT YEAR BOOK. 1922. Aeronautical Chamber of Commerce of America, New York, 1922. Cloth, 6×9 in., 251 pp., illus., diagrams, tables, $3.20.

A general review of the year's progress in aviation prepared especially for those interested in its commercial development. Contains a review of commercial aviation during the year, a discussion of the problems of aerial transportation, an account of the comparative effectiveness of aerial and naval armament, a review of aeronautics in different countries and an account of technical progress in construction during the year. The second section contains a collection of aircraft and engine designs, chiefly recent. The appendix contains information upon the aircraft trade associations, the government bureaus dealing with aviation and various commercial and historical tables.

AUTOMOTIVE REPAIR; Vol. 2 for Electrical-Service Men. By J. C. Wright. John Wiley & Sons, New York, 1922. Cloth, 6×9 in., 417 pp., illus., diagrams, $3.

The second volume of this comprehensive manual for repairmen treats of the electrical equipment of automobiles. It presents carefully detailed instructions for fifty-six electrical repair jobs, covering the derangements that occur most frequently. These are fully illustrated with drawings and photographs. In addition an account of electrical theory is given, sufficient for a thorough understanding of the functions of the electrical equipment of automotive vehicles.

BLAST FURNACE AND THE MANUFACTURE OF PIG IRON. By Robert Forsythe. Third edition revised by C. A. Meissner and J. A. Mohr. U. P. C. Book Co., New York, 1922. Cloth, 6×9 in., 371 pp., illus., diagrams, tables, $4.

Most recent writers on this subject have, in Mr. Forsythe's opinion, addressed themselves too exclusively to those acquainted with it. He therefore has written this concise statement of general principles, treated on essentially American lines, for beginners. The present edition has been revised by two expert blast-furnace managers, in order that it may present the practice of today.

CHILTON TRACTOR INDEX. July, 1922. Chilton Company, Philadelphia, 1922. Paper, 7×10 in., 336 pp., illus., $2.

Contains directories of manufacturers of tractors, of farm power-machinery, threshers, plows, cultivators, electric plants, etc., and of tractor parts and equipment. Specifications and prices of the various machines on the market are given and there are indexes of trade names. The Index is a convenient summary of technical and trade information frequently needed by makers and users of tractors and farm machinery.

CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT. 12th Annual, 1922. The American Society of Mechanical Engineers, New York, 1922. Fabrikoid, 9×12 in., 622 pp., illus., $5.

The twelfth issue of this convenient reference book appears in new form, the book now having a 7×10 in. type page and being printed on thin India paper and bound in flexible covers. In other ways the volume follows the plan of previous years. It contains catalog information, condensed, uniformly presented and illustrated, about the products of 372 manufacturers of mechanical equipment; a classified directory of manufacturers of equipment, in which 4200 firms are listed under 3300 headings; and a directory of consulting engineers, containing the names and addresses of 1000 engineers, under 400 headings. In each of these divisions the new issue shows enlargement and thorough revision.

COST CONTROL AND ACCOUNTING FOR TEXTILE MILLS. By Eugene Szepesi. Bragdon, Lord & Nagle Co., New York, 1922. Fabrikoid, 6×9 in., 441 pp., tables, $10.

This book discusses the various factors that contribute to the cost of manufacturing textiles, and methods of determining their several contributions. Describes a system of cost accounting in detail, which is adapted to the needs of manufacturers of textiles.

COTTON FACTS. Compiled and edited by Alfred B. Shepperson. Revised and enlarged by C. W. Shepperson. Shepperson Publishing Co., New York, 1921. Cloth, 4×7 in., 180 pp., portraits, map.

A convenient compilation of commercial and financial information required by those engaged in the cotton industry, which has appeared annually for forty-six years.

DAVISON'S TEXTILE "BLUE BOOK." Office edition. Thirty-fifth annual edition, July 1922 to July 1923. Davison Publishing Co., N. Y. Cloth, 7×9 in., 1670 pp., $7.50.

Covers all phases of the textile industry, including manufacturers, dealers and commission merchants in every kind of textiles, as well as dealers in textile supplies. The directory entries give concisely the location, officers, number of employees, and products of each mill, arranged geographically. This is the thirty-fifth annual edition, and has been thoroughly revised.

DESCRIPTIVE GEOMETRY. By George Young and H. E. Baxter. The Macmillan Co., New York, 1921. Cloth, 5×8 in., 310 pp., diagrams., $3.25.

Believing that the chief value of descriptive geometry lies in its imaginative quality, these authors present it so as to develop the imagination; and therefore they encourage intuitive rather than rigidly formal methods. The treatment has been kept purely abstract, in order to avoid the tendency of the subject to degenerate into practical rules and formulas; Introductory matter showing the relation of the principles under discussion to structural work is provided, and exercises to show the application of the abstract ideas to concrete, practical problems are included.

DUST EXPLOSIVES. By David J. Price and Harold H. Brown. National Fire Protection Association, Boston, 1922. Cloth, 6×9 in., 246 pp., illus., diagrams, tables, $3.

The authors of this book are engineers and chemists connected with the Bureau of Chemistry of the U. S. Department of Agriculture, who have been engaged in an investigation of dust explosions in mines and factories. In the present work they consider the nature and theory of dust explosions, what explosions have done and what has been learned by studying those that have occurred in various industries. They then discuss the measures that have proved most effective in preventing explosions or retarding their development when started. A bibliography is included.

ESSAIS DE SOUDURES AUTOGÈNE ET ELECTRIQUE DE PIÈCES DE CHAUDIÈRES. By E. Hoehn. Ch. Béranger, Paris, 1922. Paper, 6×9 in., 78 pp., illus., diagrams, 4 fr.

This report gives the results of an extensive series of tests of autogenous and electric welds as applied to boiler construction, carried out in 1921 by the Association Suisse de Propriétaires de Chaudières a Vapeur. The points investigated included the welding of flanges to tubes and boiler shells, the welding of plates at right angles, tensile tests of different forms of welds, the influence of skin on welds, the quasi-arc electric process and the strength of welded tanks.

EXPORT MERCHANDISING. By Walter F. Wyman. First edition. McGraw-Hill Book Co., Inc., N. Y., 1922. Cloth, 6×9 in., 405 pp., illus., $4.

An extended discussion of the principles upon which the American exporter should base his efforts, with advice concerning proper practical methods. Discusses all phases of exporting. Written by an experienced exporter.

FOUNDRYMEN'S HANDBOOK, based on data sheets from *The Foundry*. First, edition. Penton Publishing Co., Cleveland, 1922. Cloth, 6×9 in. 309 pp., tables, $5.

Since 1907, *The Foundry* has regularly published "data sheets," containing practical information upon matters of interest to foundrymen. The result is a large accumulation of general and scien-

tific data, specifications, formulas and recipes, which are now presented in classified form, with an index, in a convenient volume for reference use.

HAND BOOK OF CASINGHEAD GAS. By Henry P. Westcott. Third edition. Metric Metal Works, Erie, Pa., 1922 Cloth, 5×8 in., 642 pp., illus., tables, $3.75.

The author of this work has endeavored to collect, in one volume of convenient size, all the chemical, physical, and engineering information upon the extraction of gasoline from natural gas which is likely to be needed by the man in the field. It treats of the examination and leasing of gas wells, determination of their capacity and the gasoline content of the gas, gathering lines, measuring gas, compression, absorption, blending, transportation, etc. Although few radical changes in method have been developed since the preceding edition of the book appeared, many minor improvements have been made which are now described.

HANDBOOK OF THE PETROLEUM INDUSTRY. By David T. Day. John Wiley & Sons, New York, 1922. Fabrikoid, 2 vols., 6×9 in., illus., diagrams, tables, $15.

This work is written with especial reference to the engineers who produce and refine oil, but is also addressed to the public interested in the increase of production and the better utilization of our oil supply. Throughout the book attention has been directed to present conditions, and historical matter has been omitted.

JIGS, TOOLS AND FIXTURES, their Drawing and Design. By Philip Gates. D. Van Nostrand Co., New York, 1922. Cloth, 5×7 in , 195 pp., illus., diagrams, tables, $2.50.

This simple book on the drawing and design of jigs, tools and fixtures covers equipment for practically all modern machine tools. Chapters are devoted to drill jigs, milling fixtures, chucks, cutters, taps and dies, gages, press tools, etc. A chapter on office procedure is also given. The subject is presented in a simple, practical manner.

LUMBER, ITS MANUFACTURE AND DISTRIBUTION. By Ralph Clement Bryant. John Wiley & Sons, New York, 1922. Cloth, 6×9 in., 539 pp. illus., map, tables, $4.50

A text and reference book for students in lumbering, treats first of the manufacturing plant, discussing its location and arrangement, log storage, sawmill equipment, saws, handling and transfer equipment and power plants. The second section is devoted to lumber manufacture, and deals with labor, sawing and trimming, seasoning, remanufacture of lumber, lumber products, mill refuse, and fire prevention. The concluding section, upon markets and marketing, treats of lumber trade associations, grades and inspection, transportation, domestic and foreign markets, import trade and tariffs. The appendix contains a bibliography, a glossary and tables of statistics. Covers a subject upon which few general books are available.

MECHANICAL LABORATORY METHODS. By Julian C. Smallwood. Third edition. Van Nostrand Co., N. Y., 1922. Fabrikoid, 5×7 in., 423 pp., diagrams, $3.50.

A handbook for students and mechanical engineers. Part one discusses the calibration and testing of balances, gages, dynamometers, engine indicators, planimeters, meters for gases and water thermometers, calorimeters, etc. Part two gives methods for testing fuels. Part three treats of the testing of power-plant units, such as steam engines, pumps and boilers, condensers, gas producers refrigeration plants, blowers and compressors, and water motors. The new edition has been thoroughly revised and modernized.

METALLURGY OF IRON AND STEEL. Based mainly on the work of Sir Robert A. Hadfield. Sir Isaac Pitman & Sons, Ltd., London and New York, 1922. (Pitman's technical primer series.) Cloth, 4×7 in., 122 pp., illus., tables, $0.85.

This a is brief outline of the discoveries and developments on which is based modern practice in the metallurgy of iron and steel. Stress is laid upon the importance of conservation and the assistance rendered in this direction by progress in metallurgy. The book is based upon Sir Robert Hadfield's published papers, of which a list is given.

NOTES ECONOMIQUES D'UN METALLURGISTE. By Camille Cavallier. Gauthier-Villars et Cie, Paris, 1921. Paper, 6×9 in., 153 pp., 7 fr.

These brief economic discussions, by a French iron manufacturer, treat various present problems of French industry, particularly metallurgy. Such questions as the comparison between the foreign trade of France and Germany, the participation of manufacturers in national affairs and the relations of the heads of enterprises with capital and labor are treated, and the causes of and remedies for the present economic crisis are discussed in the light of long experience in industry.

OIL ENCYCLOPEDIA. By Marcel Mitzakis. John Wiley & Sons, New York, 1922. Cloth, 5×9 in., 551 pp., $6.

This encyclopedia covers a wide range of information interesting to those engaged in the oil industry. Brief articles are devoted to engineering and geological subjects, localities where oil occurs, commercial information, and the history of the industry. A brief bibliography is included. The work will be interesting to those engaged in the oil trade.

PATENT ESSENTIALS. By John F. Robb. Funk & Wagnalls Co., New York, 1922. Cloth, 6×9 in., 436 pp., plates, charts, $5.

Treats of the nature of patents, the mechanism of their procurement, claim drafting, conduct of patent cases and special proceedings, including forms. Is the work of an experienced patent attorney, but is intended for laymen who wish to understand the essentials of law and practise before the Patent Office, rather than for experts.

POWER ALCOHOL. By G. W. Monier-Williams. Frowde, London, 1922. (Oxford technical publications.) Cloth, 5×8 in., 323 pp., illus., diagrams, $7.

A complete, well-balanced account of all the problems—engineering, chemical and economic—associated with the production and utilization of alcohol as a motor fuel.

PROPERTIES OF ELECTRICALLY CONDUCTING SYSTEMS. By Charles A. Kraus. Chemical Catalog Co., New York, 1922. (American Chemical Society. Monograph series.) Cloth, 6×9 in., 415 pp., diagrams, $4.50.

Professor Kraus here presents a comprehensive systematic account of the more important conclusions reached by the study of ionic phenomena, which have hitherto been available only in scattered form, in periodicals and transactions of scientific societies. His book affords a convenient summary of the contemporary understanding of the subject, useful both to those directly engaged in studying it and to investigators in allied sciences.

REINFORCED CONCRETE SIMPLY EXPLAINED. By Oscar Faber. Henry Frowde and Hodder & Stoughton, London, 1922. (Oxford technical publications.) Cloth, 6×9 in., 77 pp., diagrams, $1.70.

Intended for readers who do not aspire to a specialist's knowledge, but want a clear understanding of the general principles involved in reinforced concrete, so as to be able to make simple designs, safe but not necessarily the last word in economy, and to take an intelligent interest in reinforced-concrete construction.

SIENCE OF PURCHASING. By Helen Hysell. D. Appleton Co., N. Y., 1922. Cloth, 5×8 in., 261 pp., $2.50.

Discusses the qualifications of a purchasing agent, the principles and policies to be adopted, the legal, economic and ethical principles to be observed, the organization and conducting of purchasing departments.

SIX-PLACE TABLES. McGraw-Hill Book Co., Inc., New York, 1922. Fabrikoid, 4×7 in., 124 pp., $1.25.

A selection of tables of squares, cubes, square roots, cube roots, fifth roots and powers, circumferences and areas of circles, logarithms of numbers, logarithms of trigonometric functions, and natural trigonometric functions. Arranged to meet the need for a volume of pocket size containing the tables in regular, continuous use by students and engineers.

SPACE—TIME—MATTER. By Hermann Weyl. E. P. Dutton & Co., New York, 1922. Cloth, 6×9 in., 330 pp., diagrams, $7.50.

Although many popular introductions to the general theory of relativity have appeared, systematic presentations are not common and for this reason this translation of the leading German work on the subject is welcome. In it are given all the details of the mathemetical reasoning required for a thorough understanding of the subject. The author's extension of the theory to include electromagnetic phenomena is given in full.

DIE STATIK DES KRANBAUES. By W. Ludwig Andrée. Third edition. R. Oldenbourg, München, 1922. Paper, 7×10 in., 370 pp., diagrams, 348 marks.

Eighty examples of static calculations for cranes and similar structures. Includes traveling, cantilever, bridge, rotary, gantry, portal, floating, tower and shipbuilding cranes, aerial ferries, cableways, hoist frames, inclined bridges, grab buckets, swing and bascule bridges. This edition is apparently a reprint of the second.

TEXT-BOOK OF THE MATERIALS OF ENGINEERING. By Herbert F. Moore. Third edition. McGraw-Hill Book Co., Inc., New York, 1922. Cloth, 6×9 in., 315 pp., illus., diagrams, $3.

A concise presentation of the physical properties of the common materials used in structures and machines, with brief descriptions of their manufacture and fabrication. Elementary in character and intended for use in technical schools in connection with courses in the mechanics of materials. Bibliographies are appended to each chapter. This edition has been revised in the light of recent experimental data.

THOMAS' REGISTER OF AMERICAN MANUFACTURERS, 13th Year, 1922. Thomas Publishing Co., New York, 1922. Cloth, 9×12 in., 4500 pp., $15.

The Register answers immediately the three usual questions that arise in every purchasing department. It contains lists of the makers of over 70,000 articles and gives the capital rating and address of each. It also furnishes a directory of manufacturers, giving their addresses, lines, branches, etc. Section Three lists over 50,000 trade named articles with the names of their manufacturers. For many years a standard directory, this edition has been carefully revised to the time of issue.

UNTERSUCHUNGEN AN DAMPFSTRAHLAPPARATEN. By F. Heinl. Julius Springer, Berlin, 1922. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens. Heft 256.) Paper, 7×10 in., 23 pp., 20 marks.

Gives the results of an investigation to determine whether the circulation in hot-water heating systems can be maintained by means of one or more injectors fed with high-pressure steam, instead of by the usual methods. The specific points examined were the heat given to the water by the injected steam, under the most favorable conditions, at any given rates of injection and pressure, and the possibility of regulating the apparatus by varying the amount of water. The tests were made upon a model system built for the purpose. A study of the action of injectors is included.

UNTERSUCHUNGEN ÜBER LAMINARE UND TURBULENTE STRÖMUNG. By L. Schiller. Julius Springer, Berlin, 1922. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens. Heft. 248.) Paper, 7×10 in., 36 pp., diagrams, 30 marks.

Gives the results of an exhaustive new investigation of laminar and turbulent flow in pipes, especially of the influence of various factors on the "critical" number. Certain variations from Poiseuille's Law were detected, which had not been noticed by previous investigators, and an explanation is provided for them.

In addition to its theoretical importance, this investigation should be of practical value, for it opens the way for the determination of viscosities by means of short tubes and makes possible the determination of absolute viscosity with the well-known Engler viscosimeter.

UNTERSUCHUNGEN UND NEUERUNGEN AN VENTILKOMPRESSOREN. By J. C. Breinl. R. Oldenbourg, München, 1922. Paper, 7×10 in., 110 pp., diagrams, illus., 252 marks.

A record of the results obtained in an extended study of air-compressor valves. Of interest to designers and manufacturers.

A NEW SYSTEM OF HELICAL GEARING FOR USE ON METAL PLANERS

(Continued from page 817)

flanks of the pinion where the tips of the gear teeth rub. Theoretically a spur gear gives tooth contact at all points lying on the line of action, and during part of the time more than one pair of teeth may be in contact. Actually, as soon as the teeth wear, only one pair of teeth will be in contact at a time. Therefore the shorter these teeth the stronger will they be. In the case of helical gearing, because of pitch-line rolling the wear is distributed equally over the entire surface of the tooth and the theoretical number of teeth always remain in contact, the effect of the wear being solely to rectify any errors in cutting and increase the backlash. The strength of helical gearing is therefore not appreciably increased by using stub teeth, since lengthening the teeth increase the effective lineal contact, which is equivalent to increasing the width of face of a spur gear. On the other hand, the greater number of teeth in contact and the longer arc of action give much smoother tooth action. Furthermore, the lower specific pressures increase the efficiency, have less tendency to break down the oil film, and greatly reduce the wear.

The 20-deg. pressure angle seems to have certain theoretical advantages over the form adopted which do not bear the test of experience. The higher pressure angle eliminates interference, reduces relative sliding and consequent friction, and gives a stronger form of tooth. However, these same advantages inhere in the tooth form adopted, and it is found that the lower-pressure-angle gears give smoother and more satisfactory action. The reason for this is threefold: In the first place, variations in friction produce much less marked variations in the direction and amount of the forces between the teeth. In the second place, the lower pressure angle reduces the objectionable vertical component of the vibration. In the third place, the low pressure angle gives a longer arc of action, more teeth in contact, and a greater effective lineal contact. The actual advantages were found to lie with the low pressure angle.

It is obviously desirable that the faces of the gears should be as wide as possible in order to increase the strength of the gearing, and reduce the specific contact pressure. Furthermore, with the low helical angle chosen for this design, wide-faced gears are necessary to secure overlapping tooth action. In order to permit of gears of maximum width of face, the rack is offset so that its center line lies to one side of the center line of the table. This permits the rack to be widened about 40 per cent and also permits the intermediate gear to be widened. The center line of the rack is placed toward the right-hand side of the planer, since the right-hand side head is the one generally used and since narrow work placed on the table is generally placed close to the operating side of the machine. In this manner the line of action of the driving force is brought nearer to the line of action of the cutting tools, reducing the tendency of the tool pressure to turn the table in a clockwise direction when viewed from above. Incidentally, the vertical component of the bull-wheel pressure tends under the usual operating conditions to counteract the downward component of the tool pressure, which, it is readily seen, would otherwise bear more heavily on the right-hand V.

Table 1, which gives the kinematic dimensions of a bull pinion, bull gear, and rack designed in accordance with the foregoing principles, will be of interest.

TABLE 1. KINEMATIC DIMENSIONS OF A PLANER BULL PINION, BULL GEAR AND RACK DESIGNED ACCORDING TO THE AUTHOR'S SYSTEM OF HELICAL INVOLUTE GEARING

	Pinion	Gear with Pinion	Gear with Rack	Rack
No. of teeth	20	80	80	∞
Pressure angle (transverse)	14°34′	14°34′	6°51′	6°51′
Base-circle diam., in.	4.862	19.45	19.45	∞
Helix angle (at pitch line)	5°40′	5°40′	5°32′	5°32′
Pitch diameter, in.	5.024	20.097	19.597	∞
Circular pitch (transverse), in.	0.78926	0.78926	0.76962	0.76962
Addendum, in.	0.375	0.125	0.375	0.125
Dedendum, in.	0.125	0.375	0.125	0.375
Angle of approach	10.9°	.....	6.35°	.....
Angle of recess	21.5°	.....	10.6°	.....
No. of teeth in action	1.8	1.8	3.75	3.75
Actual width of face, in.	8½	8½	8½	8½
Effective lineal contact, in.	15.3	15.3	32	32
Hand of helix	left	right	right	left

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada.)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ACCIDENTS

Industrial. Industrial Accidents and Hygiene. Monthly Labor Rev., vol. 15, no. 3, Sept. 1922, pp. 178–195. Problem of dust phthis in granite-stone industry and in printing industry. Heart disease in industry. Safety activity of large motor company. Mine accidents in Alaska, 1921. Fatal accidents in British coal mines, 1874–1920.

Iron and Steel Industry. Causes and Prevention of Accidents in the Iron and Steel Industry, 1910–1919, Lucian W. Chaney. U. S. Bur. of Labor Statistics, no. 298, June 1922, 398 pp., 89 figs. Results of study of accidents which have been going on in Bur. of Labor Statistics during last 10 years.

AERONAUTICAL INSTRUMENTS

Altitude. Altitude Instruments. Nat. Advisory Committee on Aeronautics. Aeronautic Instruments, Report no. 126, 1922, 64 pp., 83 figs. Part I: Altimeters and barographs. Part II: Precision altimeter design. Part III: Statoscopes and rate-of-climb indicators. Part IV: Aerographs and strut thermometers.

Power-Plant Instruments. Power Plant Instruments. Nat. Advisory Committee for Aeronautics, Aeronautic Instruments, section 5, report no. 129, 72 pp., 76 figs. Part I: Airplane tachometers. Part II: Testing of airplane tachometers. Part III: Thermometers for aircraft engines. Part IV: Air pressure and oil pressure gages. Part V: Gasoline depth gages and flowmeters for aircraft.

AIR COMPRESSORS

Design. Principles of Design of Air Compressors, William Reavell. Instn. Mech. Engrs. Proc., no. 4, June 1922, pp. 833–854, 15 figs., also Power House, vol. 15, nos. 17 and 18, Sept. 5 and 20, 1922, pp. 22–25 and 22–23, 15 figs. Influence of different types of valves; relation of clearance volume to cylinder volume; efficient cooling; single- and multiple-stage compression. Turbo-compressors and their characteristics.

Hydraulic. Producing Compressed Air by Hydrocompressors (Presslufterzeugung durch Hydrokompressoren), Carl Heirich. Bergbau, vol. 35, no. 33, Aug. 17, 1922, pp. 1177–1180, 4 figs. Necessity for compressed air in mining; construction and operation of hydro-compressors and their use in various countries.

Rotary. The Planche Rotary Compressor. Engineer, vol. 134, no. 3481, Sept. 15, 1922, p. 280, 7 figs. Describes new compressor of volumetric type and gives particulars of results obtained under test. Translated from Génie Civil.

AIRCRAFT

Design. The Preliminary Design of Aircraft. Aviation, vol. 13, no. 13, Sept. 25, 1922, pp. 381–382. Specification for an aircraft and its contradictory requirements; principal characteristics; flight characteristics of airplanes; sources of error in wind tunnel tests. Translated from Aéronautique.

AIRCRAFT CONSTRUCTION MATERIALS

Brass, Forged and Cast. Investigation of Forged and Cast Brass. Air Service Information Circular, vol. 4, no. 335, Apr. 1, 1922, 6 pp., 8 figs. Investigation to determine suitability of forged brass in gasoline pipe line and tank fittings for service use on airplanes, and to compare soundness of forged and cast brass fittings.

Radiological Inspection. Radiological Inspection Work, V. E. Pullin. Aeronautical Jl., vol. 26, no. 141, Sept. 1922, pp. 336–340 and (discussion) 340–348, 11 figs. Shows present position of radiology with regard to its usefulness in affording means of inspection of various materials, with special reference to materials and parts used in airplane construction.

AIRPLANE ENGINES

Aeromarine U873. Aeromarine Model U873 Engine, E. A. Ryder. Aviation, vol. 13, no. 16, Oct. 16, 1922, pp. 499–501, 4 figs. Model is 77 lb. lighter than U8D although of 18-per cent bigger displacement and is rated at 250 hp.

Curtiss. Curtiss Model D12 Aeronautical Engine, Arthur Nutt. Aviation, vol. 13, no. 16, Oct. 16, 1922, pp. 496–498, 4 figs. Details of new 450-hp. engine.

Fuels, Doped. Investigations of the Effect of Doped Fuels on Fuel System. Air Service Information Circular, vol. 4, no. 308, Mar. 15, 1922, 6 pp., 8 figs. Investigation to determine effect of airplane fuels, dopes, and doped fuels on fuel system, with particular attention to problem of corrosion prevention.

Packard. The Packard Model 2025 Engine. Aviation, vol. 13, no. 16, Oct. 16, 1922, p. 503, 1 fig. Details of 12-cylinder 600-hp. engine.

Radiators. Radiators for Aircraft Engines, S. R. Parsons and D. R. Harper. U. S. Bur. of Standards Technologic Papers, vol. 16, no. 211, May 26, 1922, pp. 247–430, 152 figs. Consideration of characteristics which determine value of radiator in discharging its functions. Measurements of air flow through core, of head resistance, cooling power, and geometrical characteristics; relations between these and conditions under which radiator operates, and characteristics of form and construction. Work based on special laboratory investigations, including laboratory tests of over 100 types of radiator core.

Types. Airplane Engines (Les Moteurs d'Aviation), Martinot-Lagarde. Aérophile, vol. 30, nos. 9–10, 11–12 and 13–14, May 1–15, June 1–15 and July 1–15, 1922, pp. 135–139, 171–174 and 196–200, 14 figs. Present requirements and status of research. Describes some commercial and military engines, including Hispano, Lorraine, Renault, Bristal Jupiter, Napier, Lorraine-Dietrich, Panhard-Levassor, etc., future of commercial engine; engines for high altitudes; new cycles.

AIRPLANE PROPELLERS

Experimental Research. Experimental Research on Air Propellers, W. F. Durand and E. P. Lesley. Nat. Advisory Committee for Aeronautics, Report no. 141, 1922, 82 pp., 52 figs. Results of general analysis and review of series of experimental observations of previous reports, nos. 14, 30 and 64.

Variable-Pitch. Variable-Pitch Propellers (Les hélices à pas variable), M. Lamé. Aéronautique, vol. 4, no. 38, July 1922, pp. 215–218, 7 figs. Variable-pitch propellers for different speeds, for slowing down and reversing; describes Levasseur variable-pitch propeller.

AIRPLANES

Aerofoils. Report of Wind Tunnel Tests on Aerofoils: Dayton-Wright Nos. TT-1 and TT-2, Dayton-Wright Nos. 5 and 6, and Gottingen No. 387. Air Service Information Circular, vol. 4, no. 328, Mar. 15, 1922, 24 pp., 18 figs. Tests of aerofoils to determine lift, drag, L/D center of pressure, and moments about leading edge.

The Ideal Airplane and the Junker Aerofoil (Ideal-Flugzeug und Junkersscher Flügel), G. Meyer. Motorwagen, vol. 25, no. 23, Aug. 20, 1922, pp. 436–439, 4 figs. Author points out that an ideally constructed airplane must consist of lift as well as drag-producing parts, and claims that the nearest approach to these conditions has been achieved by the Junker aerofoil.

Commercial. Report on the General Design of Commercial Aircraft, Edward P. Warner. Nat. Advisory Committee for Aeronautics Tech. Notes, no. 113, Sept. 1922, 19 pp., 1 fig. Author records his experiences during recent travels on European air lines, with regard to noise, seating arrangments, baggage accommodation, interior arrangement of cabins, pilot's position, view from cabin, safety, lavoratory accommodations, etc.

Design. Airplane Design and Performance Improvements Since the Armistice, C. N. Monteith. Soc. Automotive Engrs. Jl., vol. 11, no. 4, Oct. 1922, pp. 320–322. Outline of various features of airplane development investigation that have been prosecuted. Discusses four specific requirements for increasing speed, rate of climb and ability to reach great altitudes. Notes on variable-area and variable-camber wings; all-metal construction.

Dornier. Aerodynamic Improvement of Airplanes (Aerodynamische Verfeinerung der Flugzeuge), Motorwagen, vol. 25, no. 27, Sept. 30, 1922, pp. 525–527, 1 fig. Details of wing frame of the Dornier Comet airplane.

Gliders. Third Rhone Competition (Le troisième concours de la Rhon), S. Y. Dime. Aéronautique, vol. 4, no. 40, Sept. 1922, pp. 281–286, 16 figs. partly on p. 280. Gives short description of gliders, together with table giving manufacturer, type, length, surface, weight and other data.

Sailplanes of the First Experimental Congress of Engineless Aviation (Les planeurs du Premier Congrès expérimental d'Aviation sans moteur), Charles Dollfus. Aéronautique, vol. 4, no. 39, Aug. 1922, pp. 243–250, 14 figs. Describes gliders by Dewoitine, Deshayes, Montagne, Potez, and others; table of data of 50 gliders.

Hangars. See HANGARS.

Landing Stations. How to Lay Out and Build an Airplane Landing Field, Archibald Black. Eng. News-Rec., vol. 89, no. 13, Sept. 28, 1922, pp. 504–507, 5 figs. Notes on shape and size of plot, runway details, type and arrangemen. of buildings, drainage of field, best kind of grass and proper marking to aid pilots.

Low-Powered. Glider Results Point Way to Sport Plane Development, Edward P. Warner. Automotive Industries, vol. 47, no. 15, Oct. 12, 1922, pp. 722–723, 5 figs. Wing weight per sq. ft. cut in half as result of soaring-flight experiments. 2-hp. engine would maintain winning German machine in level flight in still air, allowing for propulsive efficiency of 70 per cent. Lessons for low-powered airplane design.

Potez X-A. The Potez X-A Triple-Engine Airplane Under Test (Le Potez X-A Trimoteur, aux essais), Aérophile, vol. 30, no. 13–14, July 1–15, 1922, pp. 209–211, 4 figs. Hispano-Suiza 180-hp. engine; load per horsepower, 6.90 kg.; speed, 170 km. per hr. Detailed description.

Pressure Distribution. Pressure Distribution Over the Rudder and Fin of an Airplane in Flight, F. H. Norton and W. G. Brown. Nat. Advisory Committee for Aeronautics, Report no. 149, 1922, 9 pp., 10 figs. Investigation carried out to determine loads which occur on vertical tail surfaces under various conditions of flight.

Racers. Characteristics of the Aircraft Entered in the Pulitzer Trophy Race. Aviation, vol. 13, no. 14,

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NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer[s] (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

Oct. 2, 1922, pp. 416–420, 6 figs. Details of Navy-Curtiss and Army-Curtiss racers, Navy-Curtis triplane, Bee-Line (Booth), Loening, Thomas-Morse and Verville-Sperry racers.

Ribs, Trussed. Design of Large Trussed Ribs. Air Service Information Circular, vol. 4, no. 312, Mar. 15, 1922, 17 pp., 10 figs. Describes satisfactory methods of design. Includes appendix in which example is worked out in detail, namely, a duralumin trussed rib for 4760-lb. corps observation airplane.

Rudder Control. The Effect on Rudder Control of Slip Stream Body, and Ground Interference, H. I. Hoot and D. L. Bacon. Nat. Advisory Committee for Aeronautics, Tech. Notes, no. 110, Sept. 1922, 7 pp., 6 figs. Investigation undertaken to determine relative effects of those factors which may interfere with rudder control of airplane, with especial reference to process of landing.

Seaplanes. See SEAPLANES.

Spars. Reinforced Ply-Wood Web Spars. Air Service Information Circular, vol. 4, no. 313, Mar. 15, 1922, 7 pp., 6 figs. Work conducted to determine adaptability of reinforced plywood web construction to spars, and also to compare relative merits of solid-web to trussed-web types.

Stability. The Effect of Longitudinal Moment of Inertia upon Dynamic Stability, F. H. Norton and T. Carroll. Nat. Advisory Committee for Aeronautics Tech. Notes, no. 115, Oct. 1922, 3 pp., 2 figs. Results of free flight tests to show whether longitudinal oscillations of standard S. E. 5A airplane are noticeably affected if its longitudinal moment of inertia is increased.

Struts. Reserve Bending Strength of Struts, R. A. Miller. Air Service Information Circular, vol. 4, no. 353, June 1, 1922, 5 pp., 1 fig. Investigation to determine comparative strength in bending of columns of various materials.

Taking Off and Landing. A Study of Taking Off and Landing an Airplane, T. Carroll. Nat. Advisory Committee for Aeronautics, Report no. 154, 1922, 7 pp., 11 figs. Results of investigation carried out for purpose of discussing various methods of effecting take off and landing, and to make direct analysis of control movements, accelerations, and air speeds during these maneuvers.

ALLOY STEELS

American Industry. Growth of American Alloy Steel Industry, Edwin F. Cone. Iron Age, vol. 110, no. 13, Sept. 28, 1922, pp. 791–793, 2 figs. Statistics since 1909. Record in alloy-steel castings; output from electric furnaces; role of heat treatment.

Characteristic Curves. The "Characteristic Curves" of a Nickel Steel and a Chromium Steel (Die "kennzeichnenden Kurven" eines Nickelstahles und eines Chromstahles), H. Jungbluth. Stahl u. Eisen, vol. 42, no. 36, Sept. 7, 1922, pp. 1392–1396, 10 figs. Discusses curves developed by Protevin and Chevenard; significance of curves.

Experimental Production. Experimental Production of Alloy Steels, H. W. Gillett and E. L. Mack. U. S. Bur. of Mines, Bul., no. 199, 1922, 79 pp., 10 figs. Deals with preparation of ingots on any of the series of steels. Describes indirect-arc furnace used in experiments. Photomicrographs.

Physical Properties. Standardization of Methods Leading to Comparative Physical Properties of Alloy Steels, R. M. Bird. Am. Soc. for Steel Treating, Trans., vol. 2, no. 12, Sept. 1922, pp. 1213–1218, 15 figs. Describes procedure adopted at Bethlehem plant of Bethlehem Steel Co. which is said to yield more truly comparable results than previous systems.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Bearing Metals. See BEARING METALS.

Nickel. See NICKEL ALLOYS.

Shrinkage-Testing Apparatus. New Forms of Apparatus for Determining the Linear Shrinkage and for Bottom-Pouring of Cast Metals and Alloys. Accompanied by Data on the Shrinkage and Hardness of Cast Copper-Zinc Alloys, F. Johnson and W. Grantley Jones. Inst. Metals advance paper for meeting Sept. 20–22, 1922, 28 pp., 11 figs.

Strontium-Lead. The Diagram of State for Strontium-Lead (Beitrag zum Zustandschaubild Strontium Blei), E. Piwowarsky. Zeit. fur Metallkunde, vol. 14, no. 7, July 1922, pp. 300–301, 3 figs. Notes on alloys of lead with heavy alkalis. Preliminary and main tests for plotting a diagram of state for strontium-lead up to content of 12 per cent strontium.

Study of. The Art of Alloying, W. Guertler. Brass World, vol. 17, nos. 8 and 9, Aug. and Sept. 1922, pp. 229–234 and 257–259, 10 figs. Method of production by fusion of technically possible and impossible alloys. Account of mixed crystal formations and their importance. Description of appearance of compounds and their effects. Physical properties as affected by increasing miscible ratios. Chart for constructive purposes and design of utilizable alloys. Translated from Zeit. fur Metalkunde, no. 9, June 1921.

White Metals. White Metals, A. H. Mundey, C. C. Bissett and J. Cartland. Inst. Metals advance paper for meeting Sept. 20–22, 1922, 25 pp., 10 figs. Review of principal classes of white metals, their composition and physical properties, chiefly in relation to their uses and manufacture. Deals with anti-friction alloys and other white metals. Photomicrographs. See also Engineering, vol. 114, no. 2962, Oct. 6, 1922, pp. 441–443, 10 figs.

ALUMINUM

Overheating, Effects of. The Effects of Over-Heating and Repeated Melting on Aluminium, W. Rosenhain and J. D. Grogan. Inst. Metals advance paper for meeting Sept. 20–22, 1922, 11 pp., 3 figs. Investigation to determine whether certain forms of treatment in melting and remelting of aluminum would bring about in metal deterioration approximating condition generally described as "burnt" aluminum. Part of research carried out for Aeronautics Research Committee. See also Engineering, vol. 114, no. 2961, Sept. 29, 1922, pp. 414–415, 3 figs.

ALUMINUM ALLOYS

Aluminum-Copper. The Copper-Rich Aluminium-Copper Alloys, David Stockdale. Inst. Metals advance paper for meeting Sept. 20–22, 1922, 14 pp., 37 figs. Two general methods of making investigations were used—the taking of cooling curves and micro-examination of quenched specimens. See (abstract) in Engineering, vol. 114, no. 2961, Sept. 29, 1922, pp. 396–398, 7 figs.

Aluminum-Molybdenum. The Adaptability of Molybdenum for the Refinement of Aluminum Alloys (Die Verwendbarkeit des Molybdäns zur Veredlung von Aluminiumlegierungen), H. Reimann. Zeit. fur Metallkunde, vol. 14, no. 5, May 1922, pp. 195–203, 19 figs. Investigation of a series of aluminum alloys with low molybdenum content and small additions of Mg, Cu and Zn, with regard to their casting, working and rolling properties, hardness, toughness, tensile strength, structure and conductivity.

Aluminum-Silicon. Properties and Manufacture of Aluminum-Silicon Alloys, Junius D. Edwards. Chem. & Met. Eng., vol. 27, no. 13, Sept. 27, 1922, pp. 654–655, 1 fig. Presents values for number of physical properties of aluminum-silicon alloys, pertinent to their commercial application.

Analysis. The Complete Analysis of Aluminium Alloys, E. W. Sheel. Metal Industry (Lond.), vol. 21, no. 9, Sept. 1, 1922, pp. 193–194. Describes process which has been used in laboratory under author's supervision, and with which he claims to have obtained excellent results. Determination of silicon, copper, tin, zinc, magnesium, iron, manganese and nickel.

Castings. Inclusions in Aluminum-Alloy Sand Castings, R. J. Anderson. U. S. Bur. of Mines, Tech. Paper, no. 290, 1922, 25 pp., 23 figs. Investigation of hard spots in connection with Bureau's work on casting losses in aluminum-alloy foundry practice. Notes on experiences at foundries; kinds and characteristics of hard spots, causes and factors affecting occurrence, composition and identification. Photomicrographs.

[See also DURALUMIN.]

AMMONIA

Specific Heat. Measurement of Specific Heat of Superheated Ammonia, E. E. Mueller. Refrig. Eng., vol. 9, no. 1, July 1922, pp. 1–3, 4 figs. Results of measurements to determine specific heat at constant pressure to an accuracy comparable with other total heat elements already determined, namely, latent heat of vaporization and specific heat of liquid.

AMMONIA COMPRESSORS

Feather-Valve. Feather-Valve Compressors of Three Types, Construction and Operation, F. L. Fairbanks. Refrig. Eng., vol. 9, no. 3, Sept. 1922, pp. 85–90 and (discussion) 90–92, 94, and 101–102, 11 figs. Test data of Boyle compressor alone, Boyle compressor with booster, motor-driven compressor, and uniflow steam-engine-driven compressor.

AMMONIA CONDENSERS

Large. The Advantages of a Large Ammonia Condenser, L. C. Miller. Power, vol. 56, no. 15, Oct. 10, 1922, pp. 568–570. Includes tables showing capacity of double-pipe condensers. Operating with high pressures.

APPRENTICES, TRAINING OF

Foundry. The Training of Molding and Foundry Apprentices in the Augsburg-Nuremberg Machine Factory, Nuremberg Works (Die Ausbildung der Former- und Gieszerlehrlinge in der Maschinenfabrik Augsburg-Nürnberg A.-G. Werk Nürnberg), Theodor Seyfried. Werkstattstechnik, vol. 16, nos. 14, 15 and 16, July 15, Aug. 1 and 15, 1922, pp. 405–414, 437–442 and 471–475, 42 figs. Detailed description of instruction course and methods.

Systems. Apprenticeship Training Program of a Large Corporation, J. F. Biehl. Indus. Management, vol. 64, no. 4, Oct. 1922, pp. 209–212 and 220, 4 figs. Describes plan of Worthington Pump Co.

AUTOMOBILE ENGINES

Air-Cooled. Air Cooled Engines Not Inherently More Economical, A. Ludlow Clayden. Automotive Industries, vol. 47, no. 12, Sept. 21, 1922, pp. 569–570. Maximum desirable mean cylinder temperature not known. Lack of data on this and other factors accounts largely for numerical superiority of designs using water-cooling. Data on area of cooling fins.

Atomizers. The Hazet Atomizer (Der Hazet-Zerstäuber), Wa. Ostwald. Allgemeine Automobil-Zeitung, vol. 23, no. 29, July 22, 1922, pp. 36–37, 7 figs. Construction and operation; has shape of cartridge which can be easily inserted above vaporizer; originally designed to eliminate back firing.

Carburetors. See CARBURETORS.

Cylinders. See CYLINDERS, Machining.

Ignition. See IGNITION.

Piston Pins. Tubing vs. Solid Stock as Material for Piston Pins, C. B. Fraser. Automotive Industries, vol. 47, no. 15, Oct. 12, 1922, pp. 713–719. Comparison of manufacturing costs difficult. Experience shows solid stock cheaper in small pins. No difference in quality when same grade of steel is used.

Pistons. See PISTONS.

Rochas. Recent Progress in Light Explosion Engines (Progrès récents du moteur léger à explosions), Charles Faroux. Bul. de la Société d'Encouragement pour l'Industrie Nationale, vol. 134, no. 7, July 1922, pp. 622–635, 3 figs. Discusses 4-stroke automobile engines of Rochas cycle, their mechanical efficiency, distribution of valves, balancing of shafts, etc.

Supercharger. A Super-Charger Engine. Autocar, vol. 49, no. 1406, Sept. 29, 1922, pp. 596–597, 5 figs. Details of Wilson single-sleeve valve engine in which both two-cycle and four-cycle principles are employed.

AUTOMOBILE FUELS

Alcohol. Motor Tests with Alcohol. Roy Alden. Oil News, vol. 10, no. 17, Sept. 5, 1922, p. 37. Exhaustive tests in India on single-cylinder engine show alcohol makes better motor fuel than gasoline; detonation eliminated. (Abstract.) Report of Imperial Motor Transport Council of India.

Detonation. Detonation Characteristics of Several Blended Motor Fuels, Thomas Midgley, Jr. and T. A. Boyd. Nat. Petroleum News, vol. 14, no. 27, July 5, 1922, pp. 59–60, 63–64 and 67–68, 5 figs. Benzol, alcohol, and kerosene combinations decided by bouncing-pin apparatus.

Types. The National Automobile Fuel (Le Carburant National), A. Mailhe. Journal des Usines à Gaz, vol. 46, no. 17, Sept. 5, 1922, pp. 257–259. Importance assumed by automotive fuels; types of fuels developed in France and Germany.

Vaporization. Vaporization of Motor-Fuels, P. S. Tice. Soc. Automotive Engrs. Jl., vol. 11, no. 4, Oct. 1922, pp. 307–314 and (discussion) 314–319 and 332, 7 figs. Summary of conditions surrounding and controlling fuel vaporization in cycle of operation of throttle-controlled internal-combustion engine fitted with intake manifold and carburetor.

[See also BENZOL; GASOLINE.]

AUTOMOBILES

Ariel. The New Ariel Nine. Autocar, vol. 49, no. 1405, Sept. 22, 1922, pp. 545–547, 7 figs. Water-cooled, two-cylinder, three-seater small car, introduced by well-known motorcycle makers.

Bignan. The 12.1 H.P. Bignan. Autocar, vol. 49, no. 1403, Sept. 8, 1922, pp. 453–454, 3 figs. French chassis having no brakes operating on rear wheels; four-cylinder engine.

Calculation. Automobile Calculations, James Watt. Automobile Engr., vol. 12, nos. 164 and 165, June and July 1922, pp. 183–191 and 216–223, 23 figs. Algebraic treatment. Calculation of engine, gearbox, clutch, axles, steering gear, road springs, brakes, frame and frame mountings, weights, etc.

Delaunay-Belleville. New 12 hp. Delaunay-Belleville. Autocar, vol. 49, no. 1405, Sept. 22, 1922, pp. 556–557, 4 figs. Little change externally, but many chassis modifications, including front-wheel brakes and overhead valve engine.

Electric Equipment. The Midgley-Scholey Electric Equipment for Motor Vehicles. Engineering, vol. 114, no. 2961, Sept. 29, 1922, pp. 392–393, 11 figs. Details of electric apparatus for starting and lighting, including dynamo, magneto, controller, starter, junction box, switchboard, battery, head, side and tail lamps.

French. New French Light Car Has Four-Cylinder Air Cooled Engine, W. F. Bradley. Automotive Industries, vol. 47, no. 12, Sept. 21, 1922, pp. 567–568, 3 figs. The S. A. R. A. represents first departure in France from conventional water cooling. Belt-driven centrifugal blower, mounted in front, forces air through cast aluminum jacket.

Lancia. New Frameless Lancia Feature of Paris Show, W. F. Bradley. Automotive Industries, vol. 47, no. 15, Oct. 12, 1922, pp. 706–708, 3 figs. Body from sheet-metal stampings so designed as to require no chassis frame; novel front axle, with helical springs in steering pivots, and exceptionally short 4 cylinder V-type engine. See also Autocar, vol. 49, no. 1406, Sept. 29, 1922, pp. 578–580, 7 figs.

Mass Production. Mass Production in British Motor Industries, Henry Obermeyer and Arthur L. Greene. Am. Mach., vol. 57, no. 14, Oct. 5, 1922, pp. 524–526, 1 fig. British manufacturers beginning to see difference between mass and standardized production. Plans to utilize facilities of big Austin plant.

Paris Show. Paris Automobile Show Largest Ever Held in France, W. F. Bradley. Automotive Industries, vol. 47, no. 15, Oct. 12, 1922, pp. 701–704, 9 figs. Tendency toward slight increase in price; smaller models; lighter reciprocating parts, especially aluminum pistons; four-wheel brakes.

Single-Track Two-Wheel. The Mauser Single-Track Automobile (Das "Einspurauto-Mauser"). Motorwagen, vol. 25, no. 25, Sept. 10, 1922, pp. 485–486, 2 figs. Describes two-wheel single-track automobile with lateral supporting wheels, which can be turned at any time into a triple-track car, by lowering the side wheels.

Springs. See SPRINGS, Automobile.

Steam Cars. Some Points on Steam Cars, F. Strickland. Autocar, vol. 49, no. 1403, Sept. 8, 1922, pp. 451–452, 3 figs. Reviews salient features of design and makes certain suggestions for possible lines of future development.

Suspensions. The Problem of Suspension, Louis Coatalen. Autocar, vol. 49, no. 1405, Sept. 22, 1922, pp. 537–541, 3 figs. Describes simple but ingenious method of ascertaining spring action, which may lead to extremely important results.

Technical Studies. Studies of the Automobile, G. B. Upton. Sibley Jl., vol. 35, nos. 4, 5–6 and 9–10, Apr., May-June and Sept.-Oct. 1921 and vol. 36, nos. 4, 5 and 6, Apr., May and June 1922, pp. 58–60

and 71, 80–81 and 10, 120–124, 58–65 and 74, 78–90 and 100, and 108–118, 17 figs. Apr.: Past and problem of present time. May-June: Load-carrying capacity of tires on hard roads. Sept.-Oct.: Tractive resistances of sand and soft soils. Apr., May and June: Power required to run a car.

Transmissions. New Electric Transmission Provides for Direct Drive. Automotive Industries, vol. 47, no. 15, Oct. 12, 1922, pp. 711–714, 5 figs. Sperry transmission has five speeds forward, two in reverse and electric braking. Direct drive obtained by automatic, electrically operated friction clutch.

Unit Construction. Some Notes on Unit Construction, F. A. Stepney Acres. Autocar, vol. 49, no. 1404, Sept. 15, 1922, pp. 401–493, 6 figs. Practical and manufacturing advantages which outweight drawbacks.

Wheel Wobble. Wheel Wobble and Other Faults in the Steering System, A. Ludlow Clayden. Automotive Industries, vol. 47, no. 14, Oct. 5, 1922, pp. 667–670, 3 figs. Explanation of several puzzling phenomena. Wobble is held to be impossible with vertical steering pivots or pivots in central plane of wheel.

AVIATION

Canada. Some Technical Aspects of Aviation in Canada, E. W. Stedman. Aeronautical Jl., vol. 26, no. 141, Sept. 1922, pp. 349–375, 24 figs. Discusses different kinds of work that can be carried out by aircraft in Canada; country to be traversed; type of machine; winter flying; engine cooling, lubrication and starting; propellers; protection of crew; temperature effects on rigging and instruments; landing on snow.

AXLES

Manufacture. Manufacturing Car and Locomotive Axles, Nathan S. Frohman. Am. Mach., vol. 57, no. 13, Sept. 28, 1922, pp. 473–477, 11 figs. Steel specifications and machining operations; inspection and tests; forging under hydraulic presses; hollow boring and heat treating. Methods employed by Pollak Steel Co.

B

BALANCING MACHINES

Rotative Bodies. New Principles in Rotative Balance, Amos F. Moyer. Soc. Automotive Engrs. Jl., vol. 11, no. 4, Oct. 1922, pp. 368–372, 9 figs. Describes balancing machine by B. L. Newkirk, of research department of Gen. Elec. Co., for measuring directly resultants for two separate ends of rotative body, without necessity of separating the standing from running balance.

BEARING METALS

Genelite. Genelite—A New Bearing Material, E. G. Gilson. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, pp. 123–124, 2 figs. Bronze material containing graphite evenly distributed throughout entire mass.

BEARINGS

Anti-Friction. New Anti-Friction Bearings. Times Trade & Eng. Supp., vol. 11, no. 220, Sept. 23, 1922, p. 41, 1 fig. Describes new form of bearing invented by German engineer which is being introduced on large scale for industrial and railway purposes; consists of white metal in which special stones are embedded.

BEARINGS, BALL

Advantages and Applications. Ball Bearings, Their Advantages and Principal Applications in Brazil (Os mancaes de espheras, suas vantagens e principaes applicaçoes no Brazil), Leopoldo Franca. Revista Brasileira de Engenharia, vol. 4, no. 1, July 1922, pp. 18–24, 8 figs. Stribeck and SKF types; reducing accidents; etc.

Roller and. Ball and Roller Bearings With Details of Their Installation, G. A. Van Brunt. Indus. Engr., vol. 80, no. 9, Sept. 1922, pp. 420–429 and 459–460, 34 figs. The various designs and construction and directions for installing them on lineshafts and machines.

BEARINGS, ROLLER

Contact Type. Rolling Contact Bearings, Tobias Dantzig. West. Machy. World, vol. 13, nos. 6 and 7, June and July 1922, pp. 216–217, 247–248. Classification of anti-friction bearings; ideal bearing, efficiency and capacity. Principles of design and construction.

Roller Inspection. Inspecting Bearing Rollers by Machine. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, pp. 94–95, 3 figs. Describes machine developed by Bock Bearing Co., Toledo, O., which automatically inspects and sorts rollers at rate of 3000 per hr.

Tapered. Can Tapered Roller Bearings be Run at High Speeds? T. V. Buckwalter. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, p. 107. Results obtained in running tapered roller bearings economically and efficiently at speeds exceeding 10,000 r.p.m.

BELT DRIVE

Maintenance-Cost Reduction. Overcoming Heavy Costs of Belt Maintenance, J. H. Rodgers. Power House, vol. 15, nos. 13 and 14, July 5 and 20, 1922, pp. 29–31 and 21–22 and 24, 11 figs. Transmission problems should be in charge of competent man; inspection should be made regularly; importance of proper alignment; lacing of joints should be carefully performed.

BENZOL

Gasoline vs. The Comparative Merits of Benzol and Gasoline as Engine Fuels, W. O. Hinckley. Soc. Automotive Engrs. Jl., vol. 11, no. 4, Oct. 1922, pp. 359–360 and (discussion) 360–362, 1 fig. Describes benzol manufacturing process; and compares specification for motor benzol with specification for gasoline; comparisons between motor benzol and gasoline in regard to end point, heat value and vapor tension. Comparative engine tests made with motor benzol and gasoline as fuel.

BLAST-FURNACE GAS

Treatment. Blast Furnace Gas. Gas & Oil Power, vol. 17, nos. 203 and 204, Aug. 3 and Sept. 7, 1922, pp. 179–180 and 197–198, 3 figs. Its treatment for use with gas engines.

BLAST FURNACES

Electric-Power Application. Utilization of Electric Power About the Blast Furnace, Gordon Fox. Elec. Jl., vol. 19, no. 9, Sept. 1922, pp. 369–371, 3 figs. Deals with application of electric power to blowing, pumping, material handling and accessories.

Modern Practice. The Bases of Modern Blast-Furnace Practice, A. K. Reese. Engineering, vol. 114, no. 2958, Sept. 8, 1922, pp. 312–316, 2 figs. Writer discusses four prime factors in modern blast-furnace practice, namely, (1) preparation of materials; (2) furnace design; (3) auxiliary equipment; and (4) method of operation. Paper read before Iron & Steel Inst.

BOILER EXPLOSIONS

Prevention. High-Pressure Steam Boiler Explosions (Du danger des cassures dans les conges des fonds emboutis des corps cylindriques), L. Cauchois. Chaleur et Industrie, vol. 3, nos. 26 and 27, June and July 1922, pp. 1377–1380 and 1448–1451, 18 figs. June: Boiler construction from standpoint of safety against explosion; describes explosion of a tubular boiler. July: Explosion of Steinmüller boiler in Finland, and of Buttner boiler; discusses boiler inspection with view to avoiding accidents.

BOILER FEEDWATER

Analysis and Purification. Rapid Analysis, Purification and Control of Industrial Waters (Analyse rapide, épuration et contrôle des eaux industrielles), P. de Vadder. Outillage, vol. 6, no. 39, Sept. 30, 1922, pp. 1280–1282. Analysis of boiler feedwater; temporary and permanent hardness; water softening.

Degasification. Corrosion—Its Cause and Cure. Power, vol. 56, no. 14, Oct. 3, 1922, pp. 532–533, 2 figs. Discusses corrosion as found in power plants and describes Kestner process and degasser, as example of European corrosion method of removing oxygen from boiler feedwater.

The Degasification of Boiler Feedwater, J. R. McDermet. Mech. Eng., vol. 44, no. 10, Oct. 1922, pp. 648–650, 7 figs. Fundamental laws governing separation of dissolved gases from water by air-tension control, and extent of their application to conventional types of feedwater-heating equipment.

Treatment. Corrosion of Walls in Steam Generators (Intorno alle corrosioni delle pareti interne dei generatori di vapore), Giuseppe Gianoli. Industria, vol. 36, no. 14, July 31, 1922, pp. 261–262. Tests made by Rauch on effect of sodium chromate and bichromate on feedwater.

Critical Study of Different Boiler-Feedwater-Purification Processes (Kritik der verschiedenen Methoden der Reinigung von Kesselspeisewasser), B. Preu. Wärme-u. Kälte-Technik, vol. 24, no. 17, Sept. 1, 1922, pp. 197–201. Writer discusses various processes and describes new process and plant, by use of which water containing large amount of soluble salts can be used as feedwater.

Extensive Boiler-Water Treating on C., M. & St. P. Ry., C. Herschel Koyl. Eng. News-Rec., vol. 89, no. 14, Oct. 5, 1922, pp. 560–562, 4 figs. Chemical treatment in bad-water district improves operating conditions. Savings soon pay for numerous plants.

Solving the Feed-Water Problem at New Orleans, O. P. Adams and Paul F. Hoots. Power, vol. 56, no. 16, Oct. 17, 1922, pp. 596–599, 2 figs. The 50,000-kw. plant of New Orleans Railway & Light Co. uses Mississippi River water for makeup with practically no trouble from scale or priming, although boilers operate at high rating. This is accomplished by lime-soda-copper as treatment in steam-heated tank and by using periodic water tests.

BOILER OPERATION

Combustion. Combustion for the Boiler Room Operator, T. H. Fenner. Power House, vol. 15, nos. 17, 18 and 19, Sept. 5, 20 and Oct. 5, 1922, pp. 19–21, 24–26 and 25–27, 7 figs. Sept. 5: Amount of oxygen necessary to burn 1 lb. of coal; draft and its measurement in inches of water. Sept. 20: Drop in pressure through brick setting of boiler; use of draft gage. Oct. 5: Formation of carbonic acid and carbon monoxide in furnace gases.

Fuel Burning and. The Economic Operation of Boilers and Burning of Fuels, Frank G. Parker. Pacific Mar. Rev., vol. 19, no. 10, Oct. 1922, pp. 564–567. Analysis of heat transfer problems and of combustion factors governing furnace, tube and stack design. Paper read before Am. Soc. Mar. Engrs.

Low-Draft Maintenance. The Draft Over the Fire, E. M. Eliot. Power, vol. 56, nos. 12 and 14, Sept. 19 and Oct. 3, 1922, pp. 446–448 and 523–526, 5 figs. Sept. 19: Importance of maintaining constant low draft over fire in case of boilers operating under forced draft. Oct. 3: How to find actual saving obtainable by various methods of maintaining it.

BOILER PLANTS

Heppenstall Co., Pittsburgh. Modern Steam Generating Plant, R. F. Keifer. Blast Furnace & Steel Plant, vol. 10, no. 10, Oct. 1922, pp. 509–519, 8 figs. Details of boiler plant of Heppenstall Forge & Knife Co.; description of building, coal bunker; coal-handling equipment; coal crusher; boilers; feedwater pumps and treatment.

BOILERS

Bent-Tube vs. Straight-Tube. Bent Tube vs. Straight Tube Boilers, Walter N. Flanagan. Assn. Iron & Steel Elec. Engrs., vol. 4, no. 7, July 1922, pp. 321–343 and (discussion) pp. 344–355, 12 figs. Presents principles involved in selection and observations of author.

Calculation. Application of Stefan's Law to Boiler Calculation (Aplicación de la ley de Stefan al calculo de calderas), Vicente Burgaleta. Anales de la Asociación de Ingenieros del Instituto Católico de Artes e Industrias, vol. 1, no. 1, Jan. 1922, pp. 39–45, 5 figs. Advocates its substitution for formulas formerly used; application to locomotives, etc.

High Pressures. Very High Pressures in Modern Practice. Power House, vol. 15, no. 19, Oct. 5, 1922, pp. 23–24, 1 fig. Central station of public service company uses boiler pressure of 400 lb. per sq. in., marking new advance in engineering practice on American continent.

Waste-Heat British Practice in Waste-Heat Utilization, C. H. S. Tupholme. Power Plant Eng., vol. 26, no. 20, Oct. 15, 1922, pp. 994–996, 2 figs. Information on waste-heat boilers, including details of new improved Spencer-Hopwood deep-nest boiler and new Kirke patent gas-fired boiler. Uses for gas-fired boiler.

BORING MACHINES

Automatic. Automatic Boring and Facing Machine. Machy. (Lond.), vol. 20, no. 522, Sept. 28, 1922, pp. 787–790, 7 figs. Details of machine developed by Butterworth & Co. for automatically performing boring, facing and similar turning operations that can be confined to tools mounted in a turret head.

BRAKES

Kunze-Knorr. The Kunze-Knorr Freight-Train Brake (Die Kunze-Knorr Güterzugbremse), Kurt Wiedemann. Zeit. des Vereines deutscher Ingenieure, vol. 66, no. 38, Sept. 23, 1922, pp. 905–919, 16 figs. Describes design of brake and points out its superiority over other types.

BRASS

Hardness. The Hardness of the Brasses, and Some Experiments on Its Measurement by Means of a Strainless Indentation, F. W. Harris. Inst. Metals advance paper for meeting Sept. 20–22, 1922, 27 pp., 12 figs. Tests to determine position of hardness-composition curve at certain points in phase field.

BUSES

Design. Some Fundamental Characteristics of Present-Day Buses, R. E. Plimpton. Soc. Automotive Engrs. Jl., vol. 11, no. 2, Aug. 1922, pp. 163–172, 12 figs. Enumeration of distinctive features of buses designed for city, inter-city and country service. Discussion of steam and electric motive power, chassis components for bus service, types of bus body, problems of heating, lighting and ventilation, fare-collection devices, etc.

[See also MOTOR BUSES.]

C

CABLEWAYS

Germany. Two Noteworthy Cableways (Zwei bemerkenswerte Drahtseilbahnen), Wernekke. Fördertechnik u. Frachtverkehr, vol. 15, no. 19, Sept. 15, 1922, pp. 248–253, 12 figs. Details of construction and operation of cableway at Cologne for conveying coal and briquettes to locomotive coaling shed; length 735 m. Cableway of German Luxemburg Mining and Metallurgical Co. at Dortmundfeld for conveying slag, coke, etc.

Gilboa Dam. Aerial Tramways Serve Mixing Plant at Gilboa Dam, Charles K. Traber. Eng. News-Rec., vol. 89, no. 15, Oct. 5, 1922, pp. 604–606, 4 figs. Rugged country makes surface roads difficult. Air lines reliable and cost less. Lines have surplus capacity. Operation undisturbed by rain or snow.

CARBURETORS

Ford. Can We Afford the Ford? George Granger Brown. Jl. Indus. & Eng. Chem., vol. 14, no. 10, Oct. 1922, pp. 972–973. Points out that average Ford touring car, driven under average conditions, gives not more than 17.5 mi. per gal. One cause for this inefficiency is said to be present carbureting system which, it is claimed, can be so improved that average Ford will give 25 mi. per gal. and operate as economically as more expensive cars.

Fuel Head. Effect of Fuel Head at Carburetor on Brake Horsepower and Brake Specific Fuel Consumption. Air Service Information Circular, vol. 4, no. 336, Apr. 1, 1922, 6 pp., 4 figs. Investigation to determine relation between fuel head at carburetor and horsepower and fuel consumption of engine, and maximum and minimum practicable heads for several types of service carburetors.

CARS

Oscillation-Recording Instrument. Oscillation

Recording Instruments in Use on the Great Northern Railway. Ry. Gaz., vol. 37, no. 10, Sept. 8, 1922, pp. 314–316, 8 figs. Details of device known as "Enregistreur Hallade," and illustration of records made therewith.

Recording Riding Qualities of Cars, F. Crocker. Ry. Rev., vol. 71, no. 14, Sept. 30, 1922, pp. 437–439, 12 figs. Describes instrument devised by author for recording oscillations. Investigation conducted on English railway equipment of car-riding qualities.

CARS, FREIGHT

Gondola. 70-Ton D. & R. G. W. General Service Gondola Car. Ry. Mech. Engr., vol. 96, no. 9, Sept. 1922, pp. 517–520, 7 figs. Describes high-capacity car of unusual design for miscellaneous bulk freight.

Steel. The Design of Modern Steel Freight Car Equipment, John A. Pilcher. Ry. Rev., vol. 71, no. 15, Oct. 7, 1922, pp. 467–475, 7 figs. General principles that should govern in steel freight-car design; suggestions for improving certain features in design; continual addition of material to enable cars to withstand rough handling detracts from earning power. Paper read before Ry. Club of Pittsburgh.

CARS, PASSENGER

Heating. A Thermostatic Control of Car Heating. Ry. & Locomotive Eng., vol. 35, no. 9, Sept. 1922, pp. 234–236, 8 figs. Electrothermostatic control developed by Vapor Car Heating Co., Chicago, principle of which consists in use of electric current whose circuit is made or broken by thermometer placed in car, to regulate flow of steam to heating pipes.

Sleepers. The New Sleepers of the International Sleeping Car Company (Les nouvelles voitures-lits de la Compagnie internationale des Wagons-Lits). Génie Civil, vol. 81, no. 12, Sept. 16, 1922, pp. 249–253, 14 figs. Design and construction; framework, chassis, roofing, etc.

CASE-HARDENING

Carburizing and Decarburizing. Carburizing and Decarburizing in Case Hardening, H. B. Knowlton. Am. Soc. for Steel Treating Trans., vol. 2, no. 12, Sept. 1922, pp. 1155–1166, 16 figs. Discussion of carburizing and decarburizing actions which make for success or failure of case-hardening method in commercial practice. Photomicrographs.

Failures Due to Improper Steel. Irregularities in Case Hardened Work Caused by Improperly Made Steel, E. W. Ehn. Am. Soc. for Steel Treating Trans., vol. 2, no. 12, Sept. 1922, pp. 1177–1202, 55 figs. Gives experiences which are results of research work during last few years in metallurgical department of the Timken Roller Bearing Co. Photomicrographs.

Materials for, Tests of. Tests of Carburizing Materials, O. A. Knight and T. C. Kern. Forging & Heat Treating, vol. 8, no. 9, Sept. 1922, pp. 420–425. Results of exhaustive series of tests on five commercial compounds, indicating decided superiority of one.

Tests. Case Hardening, A. H. d'Arcambal. Am. Soc. for Steel Treating, Trans., vol. 2, no. 12, Sept. 1922, pp. 1111–1124, 23 figs. Study of chemical reactions taking place in cyanide process of case hardening. Results of Izod notched-bar tests on well-known types of case-hardening steels.

CAST IRON

Growth during Repeated Heatings. On the Growth of Gray Cast Iron during Repeated Heatings and Coolings, Tario Kikuta. Science Reports of Tohoku Imperial Univ., 1st series, vol. 11, no. 1, Apr. 1922, pp. 1–17, 16 figs. partly on supp. plates. Three periods of growth: (1) due to decomposition of cementite; (2) due to resisting effect of gas pressure to contraction; (3) yielding to pressure of occluded gases at high temperatures. 57th Report of Iron & Steel Research Inst.

Tensile Tests. Tensile Tests of Cast Iron at Various Temperatures, J. F. Harper and R. S. Mac Pherran. Iron Age, vol. 110, no. 13, Sept. 28, 1922, pp. 793–794, 5 figs. Results of work done on annealed bars in special apparatus. Comparison with steel under similar conditions.

CASTING

Centrifugal. Chromium Alloy Steel Cast Centrifugally, L. Cammen. Iron Age, vol. 110, no. 11, Sept. 14, 1922, p. 655, 1 fig. Annealed, it has same structure as mechanically worked metal, from ingots cast in stationary molds; dendritic structure absent and grain structure small.

McConway Centrifugally Cast Steel. Foundry Trade Jl., vol. 26, no. 319, Sept. 28, 1922, pp. 257–258, 1 fig. Describes new process for production of steel disks by centrifugal and hydraulic methods direct from molten steel.

CASTINGS

Silicon-Iron. Silicon-Iron Acid-Resisting Castings, Wm. Mason. Metal Industry (Lond.), vol. 21, no. 14, Oct. 6, 1922, pp. 323–325, 6 figs. Discusses nature and uses of silicon-iron acid-resisting alloys, extensive substitution of parts made of it for earthenware in chemical plant, and scope for manufacture of castings.

CENTRAL STATIONS

Solar-Heat. Solar Heat Central Stations (Centrali elettriche ad energia solare), Carlo Boggia. Industria, vol. 36, no. 13, July 15, 1922, pp. 245–246. Describes method depending on operating turbine with CO_2 from generator heated by sun.

Superpower. The Gennevilliers Electric Power Station. Engineer, vol. 134, nos. 3480, 3481 and 3482, Sept. 8, 15 and 22, 1922, pp. 242–243, 1 fig.; 270–272, 7 figs. and 294, 4 figs. on supp. plate. Full description of station, including particulars of Babcock boilers; electric plant and equipment; buildings; etc.

CHIMNEYS

Calculation. Chimney Calculation (Schornsteinberechnung), H. de Grahl. Glasers Annalen, vol. 91, no. 4, Aug. 15, 1922, pp. 54–56 and (discussion) 56–62, 3 figs. Includes table showing comparison of 11 different calculating methods. Hoffmann's calculating method and values obtained.

CHROMIUM STEEL

Hardness. Variation of Hardness in Chromium Steels (Hårdhetens variation med värmebehandlingen hos ett kromstål), H. Rowsing and J. Sissener. Jerknontorets Annaler, vol. 107, no. 8, 1922, pp. 382–386, 8 figs. Discusses recent experiments of Portevin and Chevenard.

COAL

Patent-Fuel Manufacture. Notes on Patent Fuel, Arthur Grounds. Fuel in Sci. & Practice, vol. 124, nos. 3213, 3214 and 3221, July 28, Aug. 25 and Sept. 22, 1922, pp. 119–122, 149–151 and 174–177. July 28: Deals with various binding materials proposed as suitable for agglomeration of fine coal for manufacture of briquettes and ovoid fuel. Aug. 25: Selection of coals for briquetting and grinding of coal and pitch. Sept. 22: Research on manufacture of briquettes.

COLD STORAGE

Freezing Point of Fruits and Vegetables. Freezing Points of Fruits and Vegetables, D. B. Carrick. Ice & Refrigeration, vol. 63, no. 4, Oct. 1922, pp. 180–181. Results of investigations conducted to determine freezing point and freezing injury; description of apparatus and methods used; conditions under which experiments were conducted; data obtained on apples and potatoes.

Humidity Control. Humidity Control in Cold Storage Warehouses, Milton W. Browne. Ice & Refrigeration, vol. 63, nos. 3 and 4, Sept. and Oct. 1922, pp. 140–142 and 181–183, 2 figs. Is as important as temperatures in handling of fruits and food products in cold storage; heating capacity of air depends upon quantity of water vapor mixed with it; absolute and relative humidity; humidity, temperature and dewpoint effect; relative humidity, hygrometrical and conversion tables.

COMPRESSED AIR

Reheating. The Reheating of Compressed Air, C. R. Richards and J. N. Vedder. University of Ill. Bul., vol. 19, no. 41 (bul. no. 130), June 5, 1922, 88 pp., 22 figs., 12 tables. Investigation undertaken to determine thermodynamic efficiencies resulting from heat expended in reheating process, efficiency of external and internal combustion reheaters, performance of engine using air expansively under wide variety of operating conditions, and performance of same engine operating with steam alone, and with mixtures of air and steam.

CONDENSERS, STEAM

Corrosion of Tubes. Brass as Material for Condenser Tubes (Messing als Werkstoff für Kondensatorrohre), A. Schimmel. Zeit. des Vereines deutscher Ingenieure, vol. 66, no. 36, Sept. 9, 1922, pp. 837–840, 9 figs. Discusses kinds of corrosion, causes and nature of phenomenon, and preventive measures.

Performance. Report of an Investigation of Condenser Performance in the St. Louis Water Department, L. A. Day. Am. Water Works Assn. Jl., vol. 9, no. 5, Sept. 1922, pp. 696–702, 1 fig. Study of condensing apparatus with view of increasing vacuum on pumps.

CONVEYORS

Assembling by. Assembling by Conveyor, Warren Ordway. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, pp. 103–106, 4 figs. Recently developed assembly system for increasing production and reducing manufacturing costs.

Belt. Belt-Conveyor System in Plant of By-Products Coke Corp. (S. Chicago), H. Hilman Smith, Jr. Belting, vol. 21, no. 3, Sept. 1922, pp. 17–22, 7 figs. Many large belts used in handling coal and coke, some in open, others housed. All purchased on guaranteed-tonnage basis. Service records of belts.

Belt Conveyors in the Coal Mine, Anton M. Oliver. Coal Industry, vol. 5, Sept. 1922, pp. 405–407, 2 figs. Factors affecting carrying capacity; determination of belt pull and number of plies. Points out that belt specifications should be left to manufacturer.

Gravity. What It Pays to Know About Material Handling, W. T. Spivey. Factory, vol. 29, no. 4, Oct. 1922, pp. 395–397, 450, 452 and 454, 6 figs. Use of gravity roller conveyors.

Workshop, Railless. Railless Conveyances for Work-Shops, Richard Hänchen. Eng. Progress, vol. 3, no. 10, Oct. 1922, pp. 232–235, 11 figs. Advantages of transport without rails; hand-operated conveyances without rails; universal and lifting transport barrows; platform lorries; lifting transport lorries; portable and dirigible shop cranes; electric transport lorries.

COPPER

Elastic Limits under Stress. Elastic Limits of Copper Under Cyclical Stress Variations, H. Gough. Engineering, vol. 114, no. 2958, Sept. 8, 1922, pp. 291–293, 5 figs. Describes author's method and machine for determining fatigue range of stress from test on single specimen. Summary of report to Elasticity and Fatigue Panel of Aeronautical Research Committee.

CORROSION

Firearms. Corrosion Under Oil Films, with Special Reference to the Cause and Prevention of the After-Corrosion of Firearms, Wilbert J. Huff. U. S. Bur. of Mines, Tech. Paper, no. 188, 1922, 26 pp., 5 figs. Account and results of experiments.

Iron and Steel. The Corrosion of Iron and Steel, Robert Hadfield. Roy. Soc. Proc., vol. 101, no. A713, Sept. 1, 1922, pp. 472–486, 2 figs. Refers to wastage of world's iron and steel due to corrosion, and describes number of recent experiments carried out by author with regard to copper-steel. It is shown that small copper content, say 0.16 to 0.25 per cent, is beneficial, provided condition is that of bare metal exposed to atmospheric corrosion.

COST ACCOUNTING

Alignment Charts. The Graphical Solution of Cost and Production Problems, Ludwig Weindling. Indus. Management, vol. 64, no. 3, Sept. 1922, pp. 151–152, 2 figs. Gives examples of application of alignment charts to solution of cost and production problems.

Factory Expense Distribution. Engineering Methods Applied to Cost Finding, Robert S. Denham. Indus. Management, vol. 64, no. 3, Sept. 1922, pp. 155–159. Factory survey and expense distribution.

COUPLINGS

Flexible. Flexible Couplings, John J. Serrell. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, pp. 91–93, 4 figs. Where and how they should be used.

CRANES

Double. Double Cranes for Harbours. Eng. Progress, vol. 3, no. 10, Oct. 1922, pp. 213–215, 4 figs. Describes construction of double cranes put on market by German Machine Factory Corp. (Demag), which are particularly suitable for accelerating handling of goods.

Port-Terminal. The Port Terminal Crane, H. McL. Harding. Port & Terminal, vol. 2, no. 8, Sept. 1922, pp. 11–13, 7 figs. Discusses types of dock cranes and advantages of special port-terminal type.

CUPOLAS

Air Heaters. Heat Utilization in Cupolas with Air Heaters (Wirkungsweise und Wärmeausnutzung im Kupolofen mit Winderhitzer), H. Hörnig. Wärme, vol. 45, no. 30, Aug. 4, 1922, pp. 369–371, 2 figs. Notes on cupolas with preheated air; air heating according to regenerative system; advantages over older types. See also Giesserei-Zeitung, vol. 19, no. 36, Sept. 12, 1922, pp. 521–525 and (discussion) 525–527, 4 figs. Address before Assn. German Foundrymen.

Automatic Charging. Progress in the Construction of Automatic Cupola Stokers (Fortschritte im Bau selbsttätiger Kupolofenbeschickungen), A. F. Hager. Giesserei-Zeitung, vol. 19, no. 38, Sept. 26, 1922, pp. 553–555, 2 figs. Discusses automatic charging elevators adapted to present conditions.

Heat Balance. Heat Balance in the Cupola Furnace (Remarque sur les bilans thermiques de cubilots à fonte), J. Seigle. Révue de Métallurgie, vol. 19, no. 7, July 1922, pp. 406–415, 4 figs. Errors made in analyses of flue gas; difficulties in utilizing measures of volume or measures of pressure.

Schuermann. New Development in Cupola Construction, E. Hellmund. Iron Age, vol. 110, no. 16, Oct. 19, 1922, pp. 991–992, 3 figs. Schuermann equipment in Germany involves preheating blast and shortening time of melting. Translated from Giesserei, no. 18, 1922.

CUTTING TOOLS

Stress Determination in. An Account of Some Experiments on the Action of Cutting Tools, E. G. Coker and K. C. Chakko. Instn. Mech. Engrs. Proc., vol. 1, no. 3, 1922, pp. 567–592 and (discussions) 593–621, 28 figs. Describes experiments made by aid of polarized light to determine stresses and stress distribution in cutting tools.

CYLINDERS

Machining. Machining the Stutz D. H. Motor Cylinder and Head, Robert Mawson. Can. Machy., vol. 28, no. 14, Oct. 5, 1922, pp. 37–38, 9 figs. Jigs and fixtures used in holding parts; twelve cylinders milled at one setting; pieces easily and quickly located by means of sliding supports and spring dowels.

D

DIESEL ENGINES

Double-Acting Two-Cycle. New Double-Acting Two-Cycle Diesel Engine. Mar. Engr. & Naval Architect, vol. 45, no. 540, Sept. 1922, pp. 361–365, 5 figs. Describes experimental engine built by North British Diesel Engine Works, whose successful results have encouraged builders to proceed with construction of large unit of 2250 i.hp.; test results.

German 4-Cycle. The New M. A. N. Diesel Engine. Mar. Eng., vol. 27, no. 8, Aug. 1922, pp. 509–510, 2 figs. Four-cycle type now being built in Germany; first units to be installed on Hansa freighter.

Hydroelectric Plants, Application to. The Diesel Engine, Its Economic Value Compared With That of Other Prime Movers (Les moteurs Diesel. Leur valeur économique comparée à celle d'autres machines motrices), Alfred Buchi. Bul. Technique de la Suisse Romande, vol. 48, nos. 15, 16, 17 and

20, July 20; Aug. 5, 19 and Sept. 30, 1922, pp. 169–173, 186–189, 193–197 and 229–235, 16 figs. July 20: Application of Diesel engines in hydroelectric plants: cost comparison. Aug. 5: Comparison of Diesel engines and hydraulic power for production of alternating current. Aug. 9: Diesel engine is more economical where spare units can be used; hydraulic power is preferable for constant loads. Sept. 30: Most advantageous proportion in distribution of energy to be furnished by a system which has a Diesel-engine central station; calculation of cost of production per kw-hr.

Waste-Heat Utilization. Utilization of Exhaust-Gases. S. Snuyff. Motorship, vol. 7, no. 10, Oct. 1922, pp. 770–771, 1 fig. Investigates possibilities of effective use of Diesel-engine waste heat.

DURALUMIN

Economical Use. The Economical Use of Duralumin as a Substitute for Steel in Compression. Air Service Information Circular, vol. 4, no. 337, Apr. 1, 1922, 11 pp., 6 figs. Report, embodying study of weight ratios for common loads, lengths, and fixities, to enable designer to choose readily between duralumin and steel for lightest weight.

E

EDUCATION, ENGINEERING

Future of. The Future of Engineering Education, Chas. F. Scott. Eng. Education, vol. 13, no. 1, Sept. 1922, pp. 2–9. Points out that it should include preparatory and high school and also first few years after graduation. Lack of intelligent understanding among teachers of preparatory schools and among parents as to what engineering really is. Presidential address.

Mining and Metallurgy. Mining and Metallurgy at Yale University, George J. Young. Eng. & Min. Jl.-Press, vol. 114, no. 16, Oct. 14, 1922, pp. 682–684, 4 figs. Curricula provide for selection of fundamental subjects. Method of presentation given particular attention. Specialization subordinated to broad study.

Post-War. Engineering Education after the War, Arthur M. Greene, Jr. U. S. Bur. of Education, Bul., vol. 50, 1922, 27 pp. Deals with Students' Army Training Corps; proposed schedule of studies for four engineering courses as proposed by Committee on Educational and Special Training; schedule of studies submitted by Rensselaer Polytechnic Inst.; later developments; business administration; junior college; data from replies and catalogues.

ELECTRIC FURNACES

Aluminum-Melting. A Simple Electric Crucible Furnace for Melting Aluminium, A. Glynne Lobley. Am. Electrochem. Soc. advance paper, no. 17, for meeting Sept. 21–23, 1922, pp. 169–172, 1 fig. Describes case in which electricity was applied to melting and keeping molten of aluminum for die-casting small objects.

Closed-Crucible. New Type of French Electric Furnace, R. Sylvany. Iron Age, vol. 110, no. 12, Sept. 21, 1922, pp. 763–764. Describes furnace, based on idea of T. Levoz, used during war for production of high-speed steel. Closed crucible with only one opening for charging material and additions for pouring finished metal. Girod, Keller and Hewitt types compared. (Abstract.) Paper before Am. Foundrymen's Assn.

Design. Electric Heat, Its Generation, Propagation and Application to Industrial Processes, E. F. Collins. Am. Electrochem. Soc. advance paper, no. 22, for meeting Sept. 21–23, 1922, pp. 233–260, 13 figs. Discusses more important laws of furnace design. Overall cost of electric heating.

Electrodes. Regulation of Electrodes in Electric Arc Furnaces (La regulación de los eléctrodos en los hornos electricos de arco), Jose M. Navarrete. Anales de la Asociación de Ingenieros del Instituto Católico de Artes e Industrias, vol. 1, no. 1, Jan. 1922, pp. 13–19, 7 figs. Necessity of regulating electrodes and difficulties attending it.

Heroult. The Heroult Furnace and Its Smelting Operation (Der Heroult-Ofen und sein Schmelzbetrieb), K. Kerpely. Giesserei-Zeitung, vol. 19, nos. 34 and 35, Aug. 29 and Sept. 5, 1922, pp. 487–491 and 509–513, 10 figs. Deals with electrical conditions; lining; electric equipment; electrodes; starting fire in furnace; removal of clinker; deoxidation and desulphurization; hot charge.

High-Temperature. Principles of High Temperature Furnace Design, E. L. Smalley. Am. Electrochem. Soc., advance paper, no. 10, for meeting Sept. 21–23, 1922, pp. 77–88. Discusses attributes which electric furnaces should have, judged from viewpoints of highest quality of products, lowest cost of operation and maintenance, and greatest safety in operation at high temperatures.

Iron Founding. Melt and Anneal Electrically, Herbert R. Simonds. Foundry, vol. 50, no. 15, Aug. 1, 1922, pp. 609–612 and 621, 8 figs. Steel and malleable iron are melted in arc furnace and resistance type is employed for annealing castings.

Refractories for. Refractory Materials for Electric Furnaces, Alfred B. Searle. Beama, vol. 11, no. 4, Oct. 1922, pp. 664–670. Shows what has been done as regards refractory materials for electric furnaces and in what directions further research may usefully be conducted. It is found that newer and, as yet, not fully developed refractory materials, such as carborundum, fused alumina, zirconium and zircon, may in time replace some of those at present largely used.

Tagliaferri. Tagliaferri Furnaces in the Ansaldo Steel Works (Les fours Tagliaferri aux aciéres Ansaldo). Journal du Four Électrique et des Industries Électrochimiques, vol. 31, no. 11, Aug. 1–15, 1922, pp. 84–85, 1 fig. Operation of furnaces Nos. 4 and 5 of capacity of 6 and 10 tons, respectively, which have proved entirely satisfactory.

ELECTRIC LOCOMOTIVES

High-Speed Passenger. North-Eastern Railway Electrification. Elec. Rev., vol. 91, no. 2340, Sept. 29, 1922, pp. 436–437, 2 figs. Details of first high-speed passenger locomotives for service on British trunk-line railway.

Swiss. Electric Locomotives of the Federal Swiss Railways, Type 1B1-Bi, Constructed at Secheron Works (Locomotives électriques des Chemins de fer fédéraux suisses, type 1B1-Bi, construites par les Ateliers de Sécheron), G.-L. Meyfarth. Génie Civil, vol. 81, no. 7, Aug. 12, 1922, pp. 149–155, 16 figs; partly on supp. plate. Mechanical and electrical equipment of locomotives intended for Gothard line.

ELECTRIC RAILWAYS

Switzerland. Electric Traction on the Gottard Line (La trazione elettrica sull'intiera linea del Gottardo). Revista Tecnica della Svizzera Italiana, vol. 11, no. 6, June 1922, pp. 64–69. Advantages; principal data of construction work; hydroelectric plants; substations; electric locomotives; etc.

ELECTRIC RAILWAYS, TRACK

Urban. Urban Electric Railway Tracks, E. J. McIlrath. Eng. & Contracting, vol. 58, no. 12, Sept. 20, 1922, pp. 279–281. Principles of construction. Paper presented at City Paving Conference, Philadelphia.

ELECTRIC WELDING

Spot, Machine for. Things That Can Be Done in High-Speed Welding of Small Parts, E. H. Hubert. Indus. Engr., vol. 80, no. 9, Sept. 1922, pp. 413–415, 5 figs. Describes semi-automatic electric spot welding machine used, with procedure whereby 1000 welds an hour are made in plant of E. N. Garrison Mfg. Co., Bridgeport, Conn.

ELECTRIC WELDING, ARC

Mild Steel and Gray Castings. Experiments with Electric Arc Welding of Mild Steel and Gray Castings (Versuche über elektrische Lichtbogen-Schweissung von Flusseisen und Grauguss), H. Neese. Stahl u. Eisen, vol. 42, no. 26, June 29, 1922, pp. 1001–1013, 20 figs. For mild steel, gives experiments to determine most favorable strength of current, different methods of welding, welding apparatus, influence of composition of welding wire and power; for gray castings, experiments on difference between hot and cold welding.

ELEVATORS

Cables, Replacing. Replacing Cables on a Two to One Traction Elevator Machine, F. A. Annett. Power, vol. 56, no. 10, Sept. 5, 1922, pp. 372–375, 11 figs. Describes method which has been used successfully for number of years in cabling two-to-one traction elevators, eliminating much of hard work generally attendant with such jobs.

EMPLOYEES' REPRESENTATION

Plan. Telling Workers All About Business, George Smart. Iron Age, vol. 110, no. 15, Oct. 12, 1922, pp. 917–919, 2 figs. Employee representation has proved successful in periods of depression and prosperity at plant of American Multigraph Co.

EMPLOYEES, TRAINING OF

Edison School. Results Obtained from the Technical Courses of the Brooklyn Edison Company, F. N. Fenninger. Personnel Administration, vol. 10, no. 3, July 1922, pp. 9–11. History of plan; attendance in 1921; training and promotion; costs versus results.

EMPLOYMENT MANAGEMENT

Labor Policy. The Function of a Labor Policy, Ernest C. Gould. Indus. Management, vol. 64, no. 3, Sept. 1922, pp. 153–154 and 161. Analysis and definite statement of aims.

Personnel Planning. Organization Personnel Planning, B. A. Franklin. Indus. Management, vol. 64, no. 3, Sept. 1922, pp. 181–183. Problem of planning and scheduling personnel work.

Psychotechnical Methods. Industrial Psychotechnology (Industrielle Psychotechnik). Werkstattstechnik, vol. 16, no. 18, Sept. 15, 1922. Contains following articles: The Kinds of Adaptability Tests, W. Moede, pp. 521–530, 15 figs. The Executive Problem, G. Schlesinger, pp. 530–534. Position and Duties of an Executive from His Own Viewpoint, B. Herwig, pp. 534–537. Advertising as Educational Medium in Factory, K. A. Tramm, pp. 537–542, 9 figs. Safety in Industrial Plants, A. Haag, pp. 542–544. Psychotechnology and Advertising, Maria Schorn, pp. 544–547, 7 figs. Psychotechnical Work and Factory Management, Adolf Friedrich, pp. 547–551. Physician and Psychotechnology, B. Chajes, pp. 551–552, 2 figs. Latest Results of Psychotechnical Adaptability Tests for Telephone Service, Oskar Klutke, pp. 553–555, 3 figs. Application and Results of Psychotechnical Methods in the Osram Works, Walter Levy and Curt Piorkowski, pp. 555–559. Switchboard Operator and Switchboards, Rudolf Bronner, pp. 560–562, 3 figs. Psychotechnology in Radiotelegraphy, Rudolf Blumenthal, pp. 562–563, 1 fig. Improvement in Typewriter Design Based on Psychotechnical Principles, Alfons Schilling, pp. 563–568, 7 figs.

Small Factory. A Small Employment Department for a Small Factory. Factory, vol. 29, no. 4, Oct. 1922, pp. 392–394, 2 figs. Describes plan used by 150-man plant.

Testing for Placement. Placement of Operators through Tests, Arthur L. Mann. Personnel Administration, vol. 10, no. 2, June 1922, pp. 11–17. Describes practice of Kodak Part Works of Eastman Kodak Co. in testing young women for placement. Notes on job analysis, method of measurement, calibration of tests, establishing minimum standards, job classification, etc.

ENGINEERS

Licensing. Engineers in Many Fields Discuss Licensing. Eng. News-Rec., vol. 89, nos. 12 and 15, Sept. 21 and Oct. 12, 1922, pp. 470–472 and 616–617. Extracts from letters commenting on editorial discussion of subject published in same journal, July 6.

ENGINEHOUSES

Rectangular Concrete. New Engine House Construction on the Southern Pacific. Ry. Rev., vol. 71, no. 13, Sept. 23, 1922, pp. 405–407, 4 figs. Two rectangular concrete enginehouses, one at Mojave, Cal., and other at Indio, Cal., presenting departure from conventional design.

EVAPORATORS

High- and Low-Pressure. Evaporators in the Stationary Power Plant. Power, vol. 56, no. 12, Sept. 19, 1922, pp. 449–454, 10 figs. Deals with high-pressure and low-pressure systems, describing apparatus and showing how layout is determined by heat balance of particular plant.

F

FANS

Design. Fan Blower Design, H. F. Hagen. Am. Soc. Heating & Vent. Engrs. Jl., vol. 28, no. 5, July 1922, pp. 491–504, 9 figs. Describes methods by which forms and proportions of silentvane fan designed by author were determined. Design of fans based on theories of hydrodynamics.

FEEDWATER HEATERS

Testing. Test of a Cochrane Open Feed Water Heater, P. J. Searles. Am. Soc. Nav. Engrs. Jl., vol. 34, no. 3, Aug. 1922, pp. 430–437, 2 figs. Describes simple method of test which can be used in any power plant, is easily adaptable to any type of heater, and sufficiently accurate for all practical purposes.

FIRE PREVENTION

Equipment. Fire Protection for Industrial Plants, Charles L. Hubbard. Southern Engr., vol. 37, no. 6, Aug. 1922, pp. 46–51, 17 figs. Details regarding kind of apparatus to use for protection as applied to any building of similar type.

Fireproof Buildings. The Effects of Fire on Fireproof Buildings, Charles E. Fox. West. Soc. Engrs. Jl., vol. 27, no. 9, Sept. 1922, pp. 255–262 and (discussion) 262–266. Conclusions reached from examination of fire in 16-story Burlington building in Chicago, Mar. 15, 1922.

Recommendations. Fire Prevention and Fire Protection in Relation to the Public Water Supply, Frank C. Jordan. Am. Water Works Assn. Jl., vol. 9, no. 5, Sept. 1922, pp. 731–740 and (discussion) 740–742. Comparison of conditions in America and Europe. Author recommends elimination of shingle roofs, clean-up programs, and makes other suggestions for prevention of fires.

FLIGHT

Soaring. Gliding Experiments in Europe, 1922, Edward P. Warner. Aviation, vol. 13, no. 13, Sept. 25, 1922, pp. 376–380, 17 figs. Particulars of aircraft entered and results achieved at recent French and German gliding meets.

FLOW OF WATER

Kutter's Formula. Flow in Tennessee Checked against Hydraulic Formulas, Benjamin E. Hoxie. Eng. News-Rec., vol. 89, no. 15, Oct. 12, 1922, pp. 610–612, 4 figs. Study of these and Irrawaddy River curves indicate that Ganguillet and Kutter's formula does not allow fully for effect on C of slope and hydraulic radius.

FLUE-GAS ANALYSIS

Testing Apparatus. Heating-Gas Tester to Determine CO_2 Content and Gas Loss [Duplex-Mono (Heizgasprüfer auf CO_2-Gehalt und Casverlust [J. K. Münzer. Wärme, vol. 45, no. 31, Aug. 11, 1922, pp. 377–379, 9 figs. Describes Duplex-Mono testing apparatus for constant control of flue gas composition. Test results with original diagrams drawn from practice.

FOREMEN

Training. Experiences in Foremen Training, John Calder. Personnel Administration, vol. 10, no. 2, June 1922, pp. 3–10. Summary of experiences. Analysis of methods. Outline and results of training program.

FORGE SHOPS

Heppenstall Co., Pittsburgh. Works of the Heppenstall Forge and Knife. Forging & Heat Treating, vol. 8, no. 9, Sept. 1922, pp. 388–398, 15 figs.; 399–409, 8 figs.; 410–411, 2 figs.; and 412–413, 2 figs. First article describes modern forge plant designed and equipped to specialize in large and medium-sized forgings. Plan of plant layout shows position of equipment in each department, relation of departments and means of routing during manufacture. Second article, by R. F. Keifer, describes steam-

generating plant. Third article describes new oil-fired forge heating furnaces. Fourth article describes offices, laboratories and cafeteria. See also Iron Trade Rev., vol. 71, no. 13, Sept. 28, 1922, pp. 845–851, 9 figs.

FOUNDRIES

British. A Modern British Foundry. Eng. Production, vol. 5, no. 103, Sept. 21, 1922, pp. 271–275, 13 figs. Notes on plant and methods of Sterling Metals, Ltd., Coventry, England.

FUELS

Economy. Report on Fuel Economy. Colliery Guardian, vol. 124, no. 3220, Sept. 15, 1922, pp. 641–642. Fifth report of committee appointed by Brit. Assn. for investigation of fuel economy, utilization of coal, and smoke prevention. Deals with oil-fuel supplies; chemistry of coal; brown coal and lignites; domestic heating and cooking appliances; steam raising and power production; smoke abatement. See also Iron & Coal Trades Rev., vol. 105, no. 2846, Sept. 15, 1922, pp. 380–381.

Pacific Coast Problems. The Fuel Problems of the Pacific Coast. Mech. Eng., vol. 44, no. 10, Oct. 1922, pp. 655–659. Abridgments of following papers: The Future Fuel Supply of California, C. H. Delany; The Railway Fuel Problem of the Pacific Coast, J. C. Martin; The Marine Fuel Problem of the Pacific Coast, D. Dorward, Jr.; Conservation of the Fuel Supplies of the Pacific Coast, F. H. Sibley.

[See also COAL; OIL FUEL; PULVERIZED COAL.]

FURNACES

Doors. Furnace Doors. H. J. Trupin. Machy. (Lond.), vol. 21, no. 523, Oct. 5, 1922, pp. 20–21, 9 figs. Their design and suitability.

FURNACES, BOILER

Flue-Dust Losses. Flue-Dust Losses in Boiler Operation (Flugaschenverluste im Dampfkesselbetriebe), L. Finckh. Wärme, vol. 45, no. 25, June 23, 1922, pp. 309–311. Describes new type of baffle plates for prevention of flue-dust deposits, which is said to overcome unfavorable effect of draft.

Forced-Draft. Cast-Iron Sectional Boilers with Forced-Draft Grates (Gusseiserne Gliederkessel mit Unterwindfeuerung), Mór Réti. Gesundheits-Ingenieur, vol. 45, no. 29, July 22, 1922, pp. 373–376, 4 figs. Writer gives account of successful experiences during two years with use of forced-draft grates attached to different types of sectional boilers, for use of low-grade fuel.

Mechanical Draft. Mechanical Draft, A. W. Binns. Power Plant Eng., vol. 26, no. 19, Oct. 1, 1922, pp. 939–942, 10 figs. Its control, relation to heat transfer, gas velocity and difficulties experienced in specific installation.

Moist-Fuel Grates. Grates for Moist Fuel, Zuce Kogan. Power Plant Eng., vol. 26, no. 20, Oct. 15, 1922, pp. 989–993, 10 figs. Practical and theoretical considerations involved in design and operation.

FURNACES, ENAMELING

Gas-Fired. A New Type of Gas-Fired Vitreous Enameling Furnace, H. H. Clark. Am. Ceramic Soc. Jl., vol. 5, no. 8, Aug. 1922, pp. 478–487, 8 figs. Intermittent-type furnace having working chamber 4 ft. wide, 3 ft. high and 10 ft. long, heated by 10 burners; can be brought to working temperature in less than an hour and will turn out from 12 to 24 loads of work an hour.

The Intermittent Gas-Fired Enameling Furnace, Frederic C. Mackey. Am. Gas Jl., vol. 117, no. 12, Sept. 16, 1922, pp. 245–249 and 256, 7 figs. Compares electricity, gas, coal and oil in vitreous enameling industries, showing advantages of direct-fired gas furnace; figures compiled from production results obtained by using intermittent-type furnace.

FURNACES, HEATING

Regenerative Pit. Pit Reheating and Soaking Pit Furnaces, W.-E. Groume-Grjimailo. Iron Age, vol. 110, no. 16, Oct. 19, 1922, pp. 1013–1014, 4 figs. Removal of waste gas a primary consideration rarely achieved; principles governing rational design. From "The Flow of Gases in Furnaces," Wiley & Co., publishers.

G

GALVANIZING

Hot. Hot Galvanizing, Claude O. Kell. Am. Mach., vol. 57, no. 16, Oct. 19, 1922, pp. 605–607, 3 figs. Methods employed; design and construction of plant with suggested layout; selection and care of equipment.

Modern. What Is the Matter with Modern Galvanizing? J. A. Singmaster and G. F. Halfacre. Min. & Metallurgy, no. 190, Oct. 1922, pp. 15–16. Results of investigation show waste of materials caused by insufficient coating.

GAS ENGINES

Blast-Furnace. British Blast-Furnace Gas Engines. Power, vol. 56, no. 16, Oct. 17, 1922, pp. 608–609, 2 figs. Notes on design of large gas engines; large British engines; double-acting engines; ignition systems; future of gas engine in Great Britain.

British Blast-Furnace Gas Engines, F. Johnstone-Taylor. Iron & Coal Trades Rev., vol. 105, no. 2847, Sept. 22, 1922, pp. 422–424, 9 figs. Relation of design to reliability and efficiency. Main field of large gas engines is said to be a connection with driving blowing engines for blast furnaces, and in utilizing waste gases therefrom for power production.

Coke-Oven-Gas-Driven. Utilisation of Coke-Oven Gas by Large Gas Engines. Iron & Coal Trades Rev., vol. 105, no. 2848, Sept. 29, 1922, p. 464, 2 figs. Details of one of largest coke-oven gas-power stations in Germany, installed at Zollverein coal mine.

GAS PRODUCERS

German. New Types of Fixed- and Revolving-Grate Gas Producers (Neue Festrost- und Drehrostgaserzeuger-Bauarten), H. Gwosdz. Wärme, vol. 45, no. 31, Aug. 11, 1922, pp. 380–381, 10 figs. Details of new types designed by Goehtz and built by Keula Steel Works, Berlin-Schöneberg.

Morgan. The Morgan Gas Producer (La machine à gazéifier Morgan), L. Moutton. Arts et Métiers, vol. 75, no. 19, Apr. 1922, pp. 100–103, 3 figs. Operation and advantages.

Preheated-Air. Burning Fuel in Gas Producers with Preheated Air (L'utilisation des combustibles dans les gazogènes à fusion des cendres souffles au vent chaud), Auguste Dessemond. Révue Universelle des Mines, vol. 14, no. 3, Aug. 1, 1922, pp. 201–214, 6 figs. partly on supp. plate. Describes plant successfully run by Saint Étienne coal mining company for burning coal waste containing over 50 per cent ash.

Stokers for. Modern Mechanical Stokers and Ash-Removal Arrangements for Gas Producers, Especially for Those with Long Shafts (Neuere mechanische Roste und Aschenaustragvorrichtungen für Gaserzeuger, insbesondere für solche mit langgestrecktem Schachte), H. Gwosdz. Feuerungstechnik, vol. 10, no. 24, Sept. 15, 1922, pp. 269–273, 22 figs. Describes various new domestic and foreign arrangements.

GAS TURBINES

Hepburn-Forbes. Gas Turbine Controversy. Practical Engr., vol. 66, no. 1857, Sept. 26, 1922, p. 205. In writer's belief, Holzwarth turbine is overrated. Discusses proposed new Hepburn-Forbes system; in which sub-atmospheric, single-fluid constant-pressure cycle has been adopted.

GASOLINE

Natural Gas as Source. Design and Operation of a Low-Pressure Absorption Plant, W. P. Dykema and A. A. Chenoweth. U. S. Bur. of Mines Tech. Paper, no. 263, 1922, 42 pp., 16 figs. Deals with construction, operating methods, many changes necessitated, and difficulties encountered in recovery of gasoline from rich casing-head natural gas by absorption at low pressure. Describes large plant in Cushing oil field in Oklahoma. Bibliography on natural gas.

GEAR CUTTING

Automatic Lathes. Basic Principle and Use of Automatic Gear-Cutting Lathes (Grundsatz und Anwendung der Abwälzfräsautomaten), C. E. Berck. Werkstattstechnik, vol. 16, no. 15, Aug. 1, 1922, pp. 442–446, 16 figs. It has been shown that entirely satisfactory results can be obtained with use of automatic gear cutter on lathes.

Bevel Gears. Considerations Affecting the Design and Operation of Bevel-Gear Machines, I. H. Wright. Machy. (Lond.), vol. 21, no. 523, Oct. 5, 1922, pp. 13–15, 7 figs. Templet-formed gear teeth.

Cutting Bevel Gears. Machy. (Lond.), vol. 20, nos. 516 and 520, Aug. 17 and Sept. 14, 1922, pp. 612–615 and 735–738, 12 figs. Aug. 17: Principles governing operations of generating planers and general methods of setting up and adjusting Bilgram machine for cutting bevel gears. Sept. 14: Setting up Gleason bevel-gear generators; time required for cutting gears of different sizes and pitches.

Cutting Large Bevel Gears, Franklin D. Jones. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, pp. 116–122, 15 figs. Methods of stocking out and finishing bevel gears on single- and two-tool planers of form-copying or templet types.

GEARS

Bevel. Spiral Bevel Gears, I. H. Wright. British Machine Tool Eng., vol. 2, nos. 14, 15 and 16, Mar.-Apr., May-June and July-Aug. 1922, pp. 460–464, 490–495 and 525–528, 23 figs. Evolutionary forms of Citröen double helical, spiraloid, and spiral-type bevel gears, and their various objections and disadvantages as against true Archimedean spiral bevel. May-June: Explains mechanism of machine for cutting spiral bevel gears of Archimedean spiral type. July-Aug.: Mode of operation of Smith & Coventry spiral bevel gear planer.

Calculation. Rear-Axle Gear Calculations by the Compressive-Stress Method, Joseph Jandasek. Soc. Automotive Engrs. Jl., vol. 11, no. 4, Oct. 1922, pp. 375–379, 1 fig. Formulas for calculating greatest allowable load on pitch line for spur and bevel gears; investigation of capacity and strength of gears with straight and helical teeth; formulas for checking pitch and for computing number of teeth when compressive and bending stresses are equal.

Grinding. Gear Tooth Grinding. Machy. (Lond.), vol. 21, no. 523, Oct. 5, 1922, pp. 10–12, 7 figs. Loading of gear teeth; tooth pressure; importance of accuracy; types of machines.

Herringbone. Design of Herringbone Gears, N. Leerberg. Am. Mach., vol. 57, no. 16, Oct. 19, 1922, pp. 597–604, 10 figs. Methods of cutting; involute and cycloidal tooth forms; determination of strength and wear factors; care of gears.

Hot-Rolled. Producing Spur and Bevel Gears with Hot-Rolled Teeth. Automotive Industries, vol. 47, no. 13, Sept. 28, 1922, pp. 618–621, 5 figs. Describes machines used and methods followed in manufacture of hot-rolled gears by Anderson Rolled Gear Co., Cleveland, Ohio. Herringbone type of bevel gear among varieties made by this process. See also Eng. Production, vol. 5, no. 102, Sept. 14, 1922, pp. 253–257, 11 figs.; and Iron Age, vol. 110, no. 14, Oct. 5, 1922, pp. 861–863, 6 figs.

Teeth, Strength of. Strength of Internal Spur Gear Teeth, Douglas T. Hamilton. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, pp. 109–111, 5 figs. Brief review of improved method for determining strength. Factors governing strength; determining initial point of tooth contact; application of Lewis formula.

Tooth-Measuring Machine. Machine for Measuring Gear Teeth. Engineering, vol. 114, no. 2961, Sept. 29, 1922, p. 410, 9 figs. partly on p. 411. Describes machine for measuring errors.

GRAIN ELEVATORS

Concrete, Reconstruction. Concrete Grain Elevator Rebuilt at Chicago. Eng. News-Rec., vol. 89, no. 12, Sept. 21, 1922, pp. 483–485, 3 figs. Extensive repairs to foundations and bins of 10,000,000-bu. Northwestern elevator wrecked by explosion. New dust-removal apparatus.

GRINDING

Camshafts. Accurate Camshafts Produced by Grinding, R. Harrison. Can. Machy., vol. 28, no. 11, Sept. 14, 1922, pp. 20–22, 5 figs. Treatise on British methods; location of master cams; points to consider in obtaining accurate work.

Foundry and Steel-Mill. Grinding in Foundry and Steel Mill. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, pp. 126–130, 9 figs. Types of grinding machines used in foundries; wheel selection for snagging; arrangement of cleaning room; wheel efficiency and grinding costs; records of wheel costs; billet grinding.

Small Tools. Grinding in the Small Tool Industry. Machy. (Lond.), vol. 20, no. 519, Sept. 7, 1922, pp. 696–702, 19 figs. Grinding straight edges; sharpening cutters; grinding plug gages, micrometer parts, etc.

H

HANDLING MATERIALS

Chemical Plants. Safe Handling of Materials in Chemical Plants, W. G. Whitman. Chem. Age (N. Y.), vol. 30, no. 9, Sept. 1922, pp. 377–379. Non-chemical hazards; handling of gases and liquids; overflowing tanks; explosions. Paper read before Nat. Safety Council.

Factories. Handling the Finished Products of Industry, Graham L. Montgomery. Chem. & Met. Eng., vol. 27, no. 16, Oct. 18, 1922, pp. 779–783, 3 figs. Layout of Baltimore refinery of American Sugar Refining Co. Deals with packing bulk sugar in barrels, handling empty and filled barrels, loading bulk sugar in bags, delivering sugar to automatic package equipment, automatic filling of paper cartons, etc.

Tiering Machines. Tiering Machines. Engineering, vol. 114, no. 2959, Sept. 15, 1922, pp. 321–325, 8 figs. Describes models of portable elevators developed by Economy Engineering Co. of Chicago. Examples of use of tiering machines.

Unloading Plants. Elfa Unloading Appliances, K. Folsche. Eng. Progress, vol. 3, no. 10, Oct. 1922, pp. 228–230, 4 figs. Describes design and mode of action of mechanical appliances designed for unloading railway trucks by means of jet of liquid arranged to be directed as required and, evidently, possessing sufficient force to fulfill desired aim.

HANGARS

Belleville, Ill. The Army Airship Shed at Belleville, Ill. Aviation, vol. 13, no. 13, Sept. 25, 1922, pp. 383–384, 2 figs. Huge building, now under construction, to be 923 ft. long, 206 ft. wide and 170 ft. high; represents greatest advance to date in airship shed design.

Metal. The New Metal Hangars for Airplanes at Orly, France [Les nouveaux hangars métalliques pour avions du Centre d'aviation d'Orly (Seine)], F. Tayssier. Génie Civil, vol. 81, no. 9, Aug. 26 1922, pp. 189–191, 11 figs. partly on supp. plate. Design, construction and iron framework of the three hangars for the military aviation center.

HARDNESS

Testing. An Accurate Method of Determining the Hardness of Metals, with Particular Reference to Those of a High Degree of Hardness, R. L. Smith and G. E. Sandland. Instn. Mech. Engrs. Proc., vol. 1, no. 3, 1922, pp. 623–641, 12 figs. By knowing impression given by standard load, it is claimed to be possible, by means of a formula, to obtain ball-hardness figures, which are proportional to load required to give standard impression; this ball test fails at about 525 Brinell or 550 modified ball hardness. Includes five appendices.

HEALTH

Physician in Industry. The Physician in Industry. Nat. Indus. Conference Board, Special Report, no. 22, June 1922, 98 pp. Symposium of following articles: The Physician in Industry, C. C. Burlingame. The Physician in Industry and His Relation to Community Problems, C. E. Ford. The Medical Department in Industry, William A. Sawyer. Physical Examinations, C. H. Watson. Training for First Aid, Loyal A. Shoudy. Industrial Medical Records, E. H. Ingram. Dental Work in Industry, Voyle A. Paul. Tuberculosis and Heart Disease among Industrial Workers, W. Irving Clark, Jr.

Epidemic Diseases Among Industrial Workers, Royal S. Copeland. Standardization of End Results Following Injury, John J. Moorhead. Relation of Physician in Industry to Workmen's Compensation Laws, Frank L. Rector. Proper Recognition of Medical Opinion in Consideration and Settlement of Compensation Cases, W. B. Fisk. Eye Injuries from Compensation Standpoint, John A. Jackson. Back Injuries from Compensation Standpoint, F. E. Schubmehl. Hernia from Compensation Standpoint, Sidney M. McCurdy. Occupational Diseases from Compensation Standpoint, Frank L. Rector. Rehabilitation of Industrially Handicapped, T. Lyle Hazlett. Part of Industrial Management in an Industrial Medical Program, Magnus W. Alexander.

HELIUM

Production. Present State of Production of Helium (L'état actuel de la fabrication de l'hélion), N. Kirilov. Vie Technique et Industrielle, vol. 3, no. 36, Sept. 1922, pp. 370–371, 1 fig. Describes plant and manufacturing processes at Calgary for production of 97 per cent helium.

HUMIDITY

Equilibria of Common Substances. Humidity Equilibria of Various Common Substances, Robert E. Wilson and Tyler Fuwa. Jl. Indus. & Eng. Chem., vol. 14, no. 10, Oct. 1922, pp. 913–918, 13 figs. Discusses various types of humidity equilibrium curves, and gives curves for various substances arranged in groups of related materials, as follows: natural and artificial textile fibers, pulp and paper fibers, foodstuffs, absorbents, various forms of carbon and inorganic solids.

HYDRAULIC TURBINES

Axial Thrust. Axial Thrust in Turbines (Poussée axiale et Couple moteur dans une turbine), A. Gay. Annales de l'Énergie, vol. 2, no. 4, July-Aug. 1922, pp. 133–135, 3 figs. Equations on axial thrust of Francis turbines.

Draft Tubes Notes on the Draught Tube of a Water Turbine, Otogorô Miyagi. Soc. Mech. Engrs., Tokyo, Japan—Jl., vol. 25, no. 74, June 1922, pp. 39–50, 4 figs. Investigation of losses of energy; consideration of minimum loss and determination of best form of draft tube.

Improvements. Improvements in Design of Hydraulic Turbines (Neuerungen im Wasserturbinenbau), H. Donath. Elektrotechnischer Anzeiger, vol. 39, nos. 91, 92, 93 and 94, June 8, 10, 13 and 14, 1922, pp. 743–744, 751–752, 759–760 and 769–770, 18 figs. Describes recent patented improvements in turbines for low head and comparatively low cost.

Kaplan. Kaplan Turbines (Kaplan-Turbinen), Gustaf Molinder. Teknisk Tidskrift, vol. 52, no. 37, Sept. 16, 1922, pp. 593–601, 19 figs. Theory of Kaplan and Francis Turbines; details of efficiency tests made.

Pelton Wheels. Experiments on a Pelton Wheel and Needle-Nozzle, A. H. Gibson. Instn. Mech. Engrs. Proc., vol. 1, no. 3, 1922, pp. 643–661, 8 figs. Tests indicate that efficiency of well-designed wheel and nozzle, even of small power, may be surprisingly high.

Problems. The Hydraulic Turbine in Evolution, H. Birchard Taylor and Lewis F. Moody. Mech. Eng., vol. 44, no. 10, Oct. 1922, pp. 633–640, 10 figs. New problems created by turbine evolution. Analysis of flow in high-speed turbine. Correlation of marine propeller with hydraulic turbine. (Abridgment.)

HYDROELECTRIC DEVELOPMENTS

Chile. Hydro-Electric Development in Chile. Engineering, vol. 114, no. 2958, Sept. 8, 1922, pp. 297–298, 6 figs. partly on p. 300. Details of plant under construction in Colorado River valley, which is part of scheme to be developed later.

India. Hydro-Electric Power in India, Arthur T. Arnall. Beama, vol. 11, nos. 1 and 2, July and Aug. 1922, pp. 465–473 and 546–553, 2 figs. July: Survey of water-power resources, including details of rainfall and run-off; problems of storage, irrigation and hydraulic works. Aug.: Characteristic schemes; water power and coal; future development.

Manitoba, Canada. Great Falls Development of Manitoba Power Co., F. H. Martin. Can. Engr., vol. 43, no. 11, Sept. 12, 1922, pp. 337–341, 5 figs. Ultimate development on Winnipeg River of 168,000 hp. planned; power house being built for initial installation of three 28,000-hp. units; operating head 56 ft.; maximum height dam 70 ft.; concrete center-cone draft tubes.

HYDROELECTRIC PLANTS

California. Caribou 165,000-Volt Development, J. A. Koontz. Elec. World, vol. 80, no. 13, Sept. 23, 1922, pp. 648–652, 12 figs. Notes on 15,000-hp. impulse wheels, high-voltage lines over exceptionally rugged country and method of handling work and distributing material.

First Pit River Power Project Is Completed. Eng. News-Rec., vol. 89, no. 14, Oct. 5, 1922, pp. 570–571, 3 figs. Highest unit in continuous river development totals 90,000 hp. 202,000-volt power line 202 miles long.

Queenston-Chippawa. Queenston-Chippawa Power Development, T. H. Hogg. Engrs. & Eng., vol. 39, no. 9, Sept. 1922, pp. 310–324, 16 figs. Engineering features of development with permanent works designed for installation of 550,000 hp. How maximum efficiency was secured in use of water under 305-ft. head. Details of waterway 13 mi. long with unique type of intake to prevent ice troubles, concrete-lined canal section 8 mi. long, hydraulic turbines of 55,000 hp. cap., etc.

The Queenston-Chippawa Hydro-Electric Development. Elec. Jl., vol. 19, no. 8, Aug. 1922, pp. 312–328, 27 figs. Contains general description, by F. A. Gaby; description of 55,000-hp. turbines, F. H. Rogers; the 45,000-kva. waterwheel generators, H. U. Hart; switching equipment, L. B. Chubbuck.

Switzerland. Large Modern Hydroelectric Plants in Switzerland (I grandi impianti idroelettrici moderni in Svizzera), Giovanni Rodio. Industria, vol. 36, nos. 6, 7 and 10, Mar. 31, Apr. 15 and May 31, 1922, pp. 101–105, 122–125 and 184–186, 25 figs. Describes plant at Broc; hydraulic construction features, including barrage, dam, reservoirs, and water-level regulation.

I

IGNITION

Electric. The Principles of Electrical Ignition, W. M. Thornton. Beama, vol. 11, no. 2, Aug. 1922, pp. 524–529, 3 figs. Notes on electric ignition by jump sparks; oscillating coil sparks; break spark ignition; condenser discharge sparks.

Induction Coils and Magnetos. Electrical Ignition Apparatus for Internal-Combustion Engines, E. O. Turner. Engineering, vol. 114, no. 2960, Sept. 22, 1922, pp. 375–378, 6 figs. The induction coil is examined first, and the magneto is then considered as special type of induction coil.

IMPACT TESTING

Loads on Track Bolts. Some Interesting Tests of Impact Loads on Track Bolts. Ry. Maintenance Engr., vol. 18, no. 8, Aug. 1922, pp. 279–281, 5 figs. Describes unique method developed to determine stresses induced by train, engine and pull of wrench.

INDUSTRIAL MANAGEMENT

Charts. Measuring Growth and Shrinkage by Means of Ratio Charts, Bert E. Holmes. Indus. Management, vol. 64, no. 3, Sept. 1922, pp. 165–168, 3 figs. Said to be simplest means of graphically illustrating rate of increase or decrease in any continuing factor of industrial activities, such as sales, production, inventories, etc. Presents table for quickly placing "rate of change" lines on ratio charts.

Charting as an Aid in Stabilizing Profits, Percy A. Bivine. Indus. Management, vol. 64, nos. 3 and 4, Sept. and Oct. 1922, pp. 175–179 and 213–215. Sept.: Development of graphic service. Oct.: Control, establishment and cost of charting organization.

Cost Analyses. Establishing a Rational Basis for Industrial Analyses, Harrington Emerson. Chem. & Met. Eng., vol. 27, no. 13, Sept. 27, 1922, pp. 644–646. Analysis of costs involved in equipment, personnel and materials. Method illustrated from statistics of U. S. railroads.

Dennison Mfg. Co. The Outstanding Features of Dennison Management, H. Feldman. Indus. Management, vol. 64, nos. 2, 3 and 4, Aug., Sept. and Oct. 1922, pp. 67–73, 3 figs., 145–150 and 225–230, 4 figs. Aug.: Analyzing and anticipating cyclical movements. Sept.: Sales engineering and operation. Oct.: Production technique and personnel administration.

Inspection. Problems and Importance of Factory Inspection, John P. Meade. Monthly Labor Rev., vol. 15, no. 1, July 1922, pp. 13–23. Specific problems connected with inspection work. Paper read before Convention of Governmental Labor Officials of United States and Canada.

Labor Records. Labour Records for Small Factories, H. W. Rose. Indus. Management (Lond.), (formerly Eng. & Indus. Management), vol. 8, no. 6, Oct. 5, 1922, pp. 181–183, 7 figs. Explains systematic method of recording engagements, transfers, advancements, discharges, so as to enable works manager or other official to ascertain at all times numbers and particulars of employees in each department.

Paper-Box Factory. Description of a Department for Making Rough Boxes, H. V. S. Tingley. Taylor Soc. Bul., vol. 7, no. 5, Oct. 1922, pp. 183–193, 12 figs. Workers keep material flowing steadily through machines and piece workers complete jobs in average of 75 per cent of time allowed. Details of manufacture of box, routing, floor layout, production control, wage system and cost accounting.

Production Control. Production Control in a Tire Manufacturing Plant, W. B. Mendenhall. India-Rubber World, vol. 66, no. 5, Aug. 1, 1922, pp. 729–732, 4 figs. Notes on what has been done in standardizing and controlling product in one plant. Outline of system employed.

Production Planning. Effective Production Planning for the Drop Forge Shop, C. Oliver Wellington. Forging & Heat Treating, vol. 8, no. 9, Sept. 1922, pp. 418–420. Describes simple and economical system of production planning that controls operation not only of hammer units, but of preparatory and finishing processes during manufacture.

Purchasing. Aiding Purchasing through Production Studies, P. M. Marshall. Management Eng., vol. 3, no. 4, Oct. 1922, pp. 199–203, 8 figs. How buying is influenced by sources and supplies of materials.

The Purchasing Department, G. H. Bernard. Eng. Production, vol. 5, no. 104, Sept. 28, 1922, pp. 290–293, 9 figs. Details of system for recording essential data.

Quality Control of Products. Control of Quality of Manufactured Goods as Affected by Size of Plant, G. S. Radford. Management Eng., vol. 3, no. 4, Oct. 1922, pp. 193–198, 4 figs. Outlines methods according to which large factories can more nearly approximate advantages of smaller ones while still retaining favorable opportunities peculiar to strong establishments.

Raw-Material Control. Control of Raw Material to Suit Output, Gilbert L. Lacher. Iron Age, vol. 110, no. 12, Sept. 21, 1922, pp. 713–716 and 761–762, 9 figs. Management problems solved at Woodstock Typewriter Co. Close coördination of purchases and production. Shows forms or cards used in controlling raw and finished materials and movement through processes of manufacture.

Small Factories. Establishing a Small Engineering Works, A. Whitehead. Eng. & Indus. Management, vol. 7, nos. 16, 17 and 18, June 15, 29 and July 27, 1922, pp. 502–506, 540–542 and 571–573 and vol. 8, nos. 1, 2, 3 and 4, July 27, Aug. 10, 24 and Sept. 7, 1922, pp. 3–5, 39–41, 75–77 and 121–123, 13 figs. Planning of organization; choice of suitable site and layout of building; useful information on lighting, heating and ventilation; drawing office. Organization and system employed in some works.

Stocktaking. Perpetual Stocktaking Systems, H. W. Ross. Eng. & Indus. Management, vol. 8, no. 5, Sept. 21, 1922, pp. 147–148, 2 figs. Their value as recording accurate and reliable information.

Toolroom Organization. The Brass Check Versus the Triplicate Slip System. Indus. Management, vol. 64, no. 4, Oct. 1922, pp. 232–235. How loss of tools and loss of time may be diminished.

INDUSTRIAL RELATIONS

Improvements, Suggestions for. Industrial Relations, Carleton F. Brown. Indus. Management, vol. 64, no. 3, Sept. 1922, pp. 185–188. Suggests principles as forming nucleus for better understanding between capital and labor, and as foundation for development of other policies dictated from time to time by circumstances. Paper read before Indus. Relations Assn.

Industrial Democracy. New Spirit Guides Management, William Baum. Iron Trade Rev., vol. 71, no. 15, Oct. 12, 1922, pp. 996–998. True democracy in industry underlying principle of system which treats worker as intelligent personality. Remuneration is on basis of efficiency and quality of product. Mutual-benefit system successful. (Abstract.) Address before Soc. Indus. Engrs.

INSPECTION

Methods. Inspection Methods. Eng. & Indus. Management, vol. 7, nos. 16 and 18, June 15 and July 13, 1922, pp. 509–512 and 577–580 and vol. 8, nos. 1, 2, 3, 4 and 5, July 27, Aug. 10, 24, Sept. 7 and 21, 1922, pp. 8–12, 42–45, 78–81, 113–115 and 159–161, 35 figs. Necessity for inspection; duties of inspector; location of department. Inspection of gears; inspection gages. Tensile and hardness tests. Notched-bar tests.

INSULATORS, HEAT

Bagasse, Lumber. An Insulating Lumber from Bagasse, S. G. Roberts. Compressed Air Mag., vol. 27, no. 10, Oct. 1922, pp. 291–292, 4 figs. Notes on fabrication of celotex from sugar-cane waste. Its value as insulating material.

Refractory. Need for More Refractory Heat Insulators, Robt. D. Pike. Am. Ceramic Soc. Jl., vol. 5, no. 8, Aug. 1922, pp. 554–563, 4 figs. Commercial value of high-temperature thermal insulators, and numerical example of problem in designing flue for conducting hot gases; tentative specifications for refractory and insulating properties; proposed conductometer for measuring thermal conductivity.

2-Point. New Heat Insulating Material, G. Henry Katz. Am. Soc. Heating & Vent. Engrs. Jl., vol. 28, no. 7, Oct. 1922, pp. 733–738, 2 figs. Describes development, structure and composition of 2-Point, made of asbestos and diatomaceous earth, and portrays its effectiveness as heat insulator. Reprinted from Asbestos, June 1922.

INTERNAL-COMBUSTION ENGINES

Compound. What Can We Expect from the Compound Gas Engine? W. J. Wohlenberg. Power, vol. 56, no. 15, Oct. 10, 1922, pp. 560–562, 4 figs. It is shown that intercooling during compression in internal-combustion engine will increase its thermal efficiency and will also increase power developed by engine by 50 per cent.

Cycles. Cycles of Internal-Combustion Engines (Les cycles du moteur à combustion interne), Pierre Lorain. Technique Moderne, vol. 14, no. 8, Aug. 1922, pp. 337–344, 18 figs. Examines possible engine diagrams; comparison of cycles of Diesel and explosion engines; mixed cycles and their efficiency.

Design. The Fundamentals of Internal-Combustion Engine Design, L. H. Pomeroy. Soc. Automotive Engrs. Jl., vol. 11, no. 4, Oct. 1922, pp. 328–332 and (discussion) 354. Factors affecting performance of four-stroke-cycle engines; thermal efficiency and power obtainable from given engine said to be dependent upon compression-ratio, other things being equal; engine speed and friction losses. Author favors short-stroke engine.

Gaseous Detonation. The Chemical Control of Gaseous Detonation with Particular Reference to the Internal-Combustion Engine, Thomas Midgley and T. A. Boyd. Jl. Indus. & Eng. Chem., vol. 14, no. 10, Oct. 1922, pp. 894–898, 1 fig. Discusses bearing of gaseous detonation on operation of internal-combustion engines, and progress made in controlling it by chemical means.

Rotary, Forces in. Forces in Rotary Motors, Karl H. White. Mech. Eng., vol. 44, no. 10, Oct. 1922, pp. 643–647 and 654. Deals with determination of forces in rotary motor caused by reciprocation of pistons and connecting rods and by rotation of motor as a whole, in which novel methods of calculation are employed.

Vegetable Oils for. Using Vegetable Oils in Internal-Combustion Engines (Note au sujet de l'utilisation des huiles végétales dans les moteurs à combustion interne). Bul. Technique du Bureau Veritas, vol. 4, no. 7, July 1922, pp. 159–161, 5 figs. Results of tests carried out with engines by Gardner, Kromhout, Ansaldo, and Anglo-Belgian Co.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; OIL ENGINES.]

IRON

Mechanical Properties. Mechanical Properties of Commercial Iron, Zay Jeffries and R. S. Archer. Chem. & Met. Eng., vol. 27, no. 14, Oct. 4, 1922, pp. 694–697, 1 fig. Definitions of various terms used in art of testing materials, and discussion of how various circumstances surrounding test affect results on annealed bars of common structural metals.

IRON ALLOYS

Electrolytic. The Preparation and the Mechanical Properties of Vacuum-Fused Alloys of Electrolytic Iron with Carbon and Manganese, Robert P. Neville and John R. Cain. Am. Electrochem. Soc. advance paper, no. 20, for meeting Sept. 21–23, 1922, pp. 203–218, 2 figs. Describes preparation and mechanical properties of extensive series of very pure alloys of electrolytic iron, carbon, and manganese, whose compositions were so chosen as to bring out specific effects on pure iron of additions of carbon and manganese separately or together.

IRON CASTINGS

Annealing. Experiments for the Determination of the Critical Temperature in the Annealing of Gray-Iron Castings (Ueber Versuche zur Bestimmung der kritischen Temperatur beim Glühen von Grauguss), Emil Schüz. Stahl u. Eisen, vol. 42, no. 39, Sept. 28, 1922, pp. 1484–1488, 7 figs. Influence of phosphorus and graphite on hardness; importance of pearlite; examples of decomposition of cementite; testing arrangement for determination of critical temperature. Practical and theoretical conclusions.

L

LABOR

Production and Efficiency. Production and Efficiency of Labor. Monthly Labor Rev., vol. 15, no. 1, July 1922, pp. 89–92. Idle-day costs in coal-mining industry; production per worker in iron mines of Lorraine; operations of British coal mines, January 1 to April 1, 1922.

Twelve-Hour Shift. F.A.E.S. Report States Facts on Twelve-Hour Shift. Mech. Eng., vol. 44, no. 10, Oct. 1922, pp. 681–686, 2 figs. Committee on work periods in continuous industries presents report, entitled Twelve-Hour Shift in Industry, embodying investigations by Horace B. Drury and Bradley Stoughton.

Two-Shift System. The Twelve-Hour Shift in American Industry. Management Eng., vol. 3, no. 4, Oct. 1922, pp. 205–212, 3 figs. Summary report of special committee of Am. Engineering Council, purpose of which is to show extent of two-shift work and experience of those manufacturers who have changed from two-shift operation to some other system.

LOCOMOTIVE BOILERS

Fireboxes. Relative Value of Steel and Copper Fireboxes, Paul Conté. Boiler Maker, vol. 22, no. 9, Sept. 1922, pp. 253–255, 3 figs. Tests of locomotive boilers on European Railroads indicate that steel fireboxes give longer service. Abstract from Revue Générale des Chemins de Fer.

Tubes. Application and Maintenance of Locomotive Boiler Tubes, G. H. Woodroffe and C. E. Lester. Ry. Rev., vol. 71, no. 10, Sept. 2, 1922, pp. 306–311, 8 figs. Practical suggestions recommended, based on best practice observed on number of railroads.

Water Circulation. Increasing Locomotive Boiler Efficiency by Proper Circulation of Water, F. G. Lister. Boiler Maker, vol. 22, no. 9, Sept. 1922, pp. 256–257. Notes on thermic syphon, Harter circulating plate, washout and refilling system. (Abstract.) Paper read before Int. Fuel Assn.

LOCOMOTIVES

Alloy-Steel Parts. Alloy Steel Reduces Weight of Locomotive Parts, R. J. Finch. Ry. Mech. Engr., vol. 96, no. 10, Oct. 1922, pp. 569–571, 3 figs. Rods, axles and crankpins made lighter and dynamic augment reduced on Union Pacific No. 7000 by using carbon vanadium steel.

Booster. Dynamometer Tests of the Locomotive Booster. Ry. Mech. Engr., vol. 96, no. 10, Oct. 1922, pp. 562–565, 8 figs. Severe trials carried out at Engineering School of Harvard University demonstrate reliability at heavy loads and high speeds. Maximum drawbar pull 11,000 lb.

British vs. American. British and American Locomotive Design and Practice. Some Comparative Comments Thereon from Practical Experience, P. C. Dewhurst. Inst. Mech. Engrs. Proc., vol. 1, no. 3, 1922, pp. 375–423 and (discussions) 424–511, 18 figs. Author discusses comparative methods and practices in regard to structural and detail design, and indicates what in his opinion are best features of two partly opposing systems of locomotive engineering.

Design. Avoidable Waste in Locomotive Operation as Affected by Design, James Partington. Assn. Chinese & Am. Engrs. Jl., vol. 3, no. 4, Apr.-May, 1922, pp. 16–21. Study of design with regard to fuel economy, minimum weight of motive-power equipment, and minimum cost of repairs.

4-4-0. Rebuilt Express Locomotives—London, Brighton & South Coast Railway. Ry. Gaz., vol. 37, no. 11, Sept. 15, 1922, pp. 338–340, 6 figs. Reconstruction of class B4 engines of 4-4-0 type, rendering them suitable for efficiently working heavy, fast passenger trains.

Fuel Consumption. Effect of Tonnage and Speed on Fuel Consumption, J. E. Davenport. Ry. Mech. Engr., vol. 96, no. 10, Oct. 1922, pp. 565–569, 8 figs. Ton miles per hour affects fuel rate; economical tonnage for various speeds, effect of grade and car weight. (Abstract.) Paper presented before Int. Ry. Fuel Assn.

Internal-Combustion. Gasoline Switching Locomotive with Hydraulic Drive. Ry. Mech. Engr., vol. 96, no. 9, Sept. 1922, pp. 503–506, 7 figs. Universal oil transmission governs speed and direction and is said to give remarkable flexibility of control.

Luttermöller. Recent Innovations on Standard Gauge Locomotives for Facilitating the Traversing of Curves, Suren ter Ohanessian. Eng. Progress, vol. 3, no. 10, Oct. 1922, pp. 230–232, 6 figs. Comparison of Mallet, Klienlindner and Luttermöller types, showing advantages of latter.

Mikado. New Michigan Central Mikado Has Many Special Features. Ry. Mech. Engr., vol. 96, no. 9, Sept. 1922, pp. 497–501, 5 figs. Details of new Mikado type, no. 8000; special features of construction; comparative data for class H7E and no. 8000.

Some Important Innovations in New Lima Mikado Locomotive. Ry. Rev., vol. 71, no. 10, Sept. 2, 1922, pp. 302–306, 3 figs. Gives outstanding features and principal dimensions of locomotive no. 8000.

The Michigan Central's Mikado (2-8-2) Type Locomotive No. 8000. Ry. & Locomotive Eng., vol. 35, no. 9, Sept. 1922, pp. 227–230, 2 figs. Further details of its design and construction; list of economic and efficiency-producing specialties used on engine; tractive effort with boosters, 74,500 lb., without boosters, 63,500 lb.

Mountain-Type. Service Records of U. P. Mountain Type Locomotives. Ry. Age, vol. 73, no. 16, Oct. 14, 1922, pp. 687–689, 6 figs. Performance indicates that no. 7000 exceeds both theoretical starting and horsepower capacity. Weighs 345,000 lb. and develops 3500 hp. at 50 mi. per hr. See also Ry. Rev., vol. 71, no. 16, Oct. 14, 1922, pp. 509–514, 14 figs.

Pacific. Test of the New "Pacific" Locomotive, No. 1471, on the Great Northern Railway. Ry. Gaz., vol. 37, no. 13, Sept. 29, 1922, pp. 388–389, 2 figs. Hauled test load of 20 passenger coaches, weighing 610 tons, a distance of 105½ mi. in 122 min.

Power Estimation. Locomotive Power, E. C. Poultney. Engineer, vol. 134, no. 3480, Sept. 8, 1922, pp. 248–250, 6 figs. Describes method of quickly obtaining probable drawbar pull of any steam locomotive of conventional design at all speeds usual in practice.

Steam Desaturators. Steam Desaturators Applied to Hungarian Motive Power, Desider Ledacs Kiss. Ry. Rev., vol. 71, no. 15, Oct. 7, 1922, pp. 475–478, 6 figs. Describes Stein desaturator, a water intercepting device located in steam dome, successfully applied to large number of foreign locomotives. Improves locomotive efficiency in bad-water district.

Superheater. Locomotives for the Chemins de Fer du Midi. Engineering, vol. 114, no. 2960, Sept. 22, 1922, pp. 360–362, 14 figs. partly on supp. plate. Details of two-cylinder superheater 4-6-2 locomotives constructed by Société Alsacienne de Constructions Mécaniques, Belfort, France.

Tank. New "Baltic" Tank Locomotives, Glasgow & South Western Railway. Ry. Gaz., vol. 37, no. 3, July 21, 1922, pp. 90–91, 2 figs. Particulars of work performed under test conditions.

Test Results. Results of Tests with Steam Locomotives (Versuchsergebnisse mit Dampflokomotiven), R. Sanzin. Verkehrstechnik, vol. 39, no. 38, Sept. 22, 1922, pp. 481–485. Tests for determination of maximum tractive effort at drawbar; power of cylinders; adhesion and power of boiler; gives types of construction and their dimensions; results of tests for wet and dry steam.

2-8-2. America's Most Efficient Locomotive. Ry. Gaz., vol. 37, no. 12, Sept. 22, 1922, pp. 367–370, 4 figs. 2-8-2-type locomotive introduced on Michigan Central R. R. realizes maximum power development and effects great economy in fuel.

Uniflow. The Una-Flow Locomotive—A Pracitcal Possibility. Ry. Rev., vol. 71, no. 11, Sept. 9, 1922, pp. 333–338, 8 figs. Explains basis for superior economy of uniflow engine; what has been accomplished toward practical application of its principle to European motive power; practical maintenance and operating features. Compiled principally from J. Stumpf's book.

LUBRICANTS

Oiliness. The Measurement of the Property of Oiliness, Robert E. Wilson and Danile P. Barnard. Soc. Automotive Engrs. Jl., vol. 11, no. 2, Aug. 1922, pp. 143–157, 17 figs. Describes variety of possible methods of measuring property of oiliness and of throwing light on mechanism of partial lubrication. It is concluded that static-friction test with proper refinements is best single measure of properties of oiliness.

LUBRICATION

Bearings. Bearing Design and Lubrication, William Foot. Elec. Jl., vol. 19, no. 9, Sept. 1922, pp. 367–382, 18 figs. Notes on action of oil films, and of a perfect film; starting conditions; application of lubricant; methods of cooling; oil protection; bearing losses and temperature; insulation of bearing pedestals; protection from dust, dirt and scale.

Plant. The Technical Supervision of Plant Lubrication, Allen F. Brewer. Indus. Management, vol. 64, nos. 3 and 4, Sept. and Oct. 1922, pp. 141–144 and 221–223, 6 figs. Suggestions to plant lubricating engineer. Determination of correct lubricant and minimum amount to use for safe and uninterrupted operation.

M

MACHINE SHOPS

Standardized Equipment. Standardizing machine Shop Equipment, H. L. Wheeler. Am. Mach., vol. 57, no. 14, Oct. 5, 1922, pp. 520–521, 3 figs. Advantages are said to justify cost; successful method of improving old tools; tapers reduced to one standard and two sizes.

MACHINE TOOLS

Chip Disposal. Chip Disposal, F. Horner. Eng. Production, vol. 5, no. 102, Sept. 14, 1922, pp. 247–251, 17 figs. Notes on shape of edge and chip escape; objection to large chips; packing in slots and holes; interference with machine elements; chip-collecting removing devices; chip accommodation in flutes; guards and receptacles; fixed pans versus portable; storage within machine framings.

MALLEABLE CASTINGS

Handling. Handling Malleable Castings, Herbert R. Simonds. Foundry, vol. 50, no. 18, Sept. 15, 1922, pp. 733–736, 4 figs. Methods adopted in prominent Eastern foundry, including use of lift trucks and raised platforms, which have expedited work and reduced operating expenses.

Standardization. The Status of Standardization of Gray-Iron and Malleable Castings (Bericht über den Stand der Normung von Grau- und Temperguss), Rudolf Stotz. Giesserei-Zeitung, vol. 19, no. 37, Sept. 19, 1922, pp. 537–544, 15 figs. Critical discussion of quality regulations for gray-iron castings. Proposals for quality regulations for malleable iron. Foreign standards. Address before Assn. German Foundrymen.

MANGANESE STEEL

Castings. Pearlitic and Sorbitic Manganese Steels, John H. Hall. Iron Age, vol. 110, no. 13, Sept. 28, 1922, pp. 786–788. Plea for castings containing about 1 per cent manganese. Their heat treament and properties. Review of literature on subject.

METALS

Behavior in Low Temperature. The Behavior of Solid Bodies in Very Low Temperatures (Das Verhalten fester Körper in sehr tiefen Temperaturen), Walther Meissner. Zeit. des Vereines deutscher Ingenieure, vol. 66, nos. 36 and 37, Sept. 9 and 16, 1922, pp. 845–847 and 876–878, 2 figs. Points out that at very low temperatures the specific heat, thermal expansion, electrical resistance of pure metals, and thermoelectric energy, become very low; whereas thermal conductivity of metals and crystals and magnetic susceptibility become very great. All of these properties, to extent of our present knowledge, become independent of temperature in vicinity of absolute zero.

Fatigue. Recent Developments in Fatigue of Metals, H. F. Moore and T. M. Jasper. Iron Age, vol. 110, no. 13, Sept. 28, 1922, pp. 779–784, 9 figs. Effects of heat treatment; testing machine now used; endurance limit defined; machine design and localized stress.

Grain Size and Diffusion. Grain-Size and Diffusion, J. H. Andrew and Robert Higgins. Inst. Metals advance paper for meeting Sept. 20–22, 1922, 10 pp., 18 figs. Experiments were conducted which show relation between grain growth and diffusion; diffusion at high temperatures may take place simultaneously with grain growth, while at low temperatures diffusion promotes breakdown in grain size. Photomicrographs.

Mechanical Properties. Effect of Temperature, Pressure and Structure on Mechanical Properties of Metal, Zay Jeffries and R. S. Archer. Chem. & Met. Eng., vol. 27, no. 15, Oct. 11, 1922, pp. 747–751, 5 figs. Study of mechanical properties of single crystals.

Mechanical Properties As Affected by Grain Size, Zay Jeffries and R. S. Archer. Chem. & Met. Eng., vol. 27, no. 16, Oct. 18, 1922, pp. 789–792, 2 figs. Points out that grain boundaries add certain stiffness to metallic aggregate; fine grain therefore generally involves higher tensile strength and hardness, and greater reduction area; maximum elongation requires medium grain size.

Polishing. Principle of Metal Polishing, Bradford H. Divine. Machy. (N. Y.), vol. 29, nos. 1 and 2, Sept. and Oct. 1922, pp. 12–13 and 134–135, 2 figs. Sept.: General principles of metal polishing, polishing wheels and abrasives, methods and equipment, and making of polishing wheels. Examples of polishing practice. Oct.: Properties of glue for polishing wheels.

MILLING

Locomotive Main Rods. Milling Locomotive Main Rods. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, pp. 98–101, 8 figs. Results of tests made to determine possiblities of reducing costs in railroad shops by milling.

MOTOR BUSES

Trolley. The Railless Trolley Bus. Indian Industries & Power, vol. 19, no. 11, July 1922, pp. 405–407, 6 figs. Details of bus produced by Assoc. Equipment Co., Ltd.

White Coach Body. White's New De Luxe Coach Body Follows Foreign Bus Design. Commercial Vehicle, vol. 27, no. 5, Oct. 1, 1922, pp. 28–29, 4 figs. Has enclosed drawing room and open forward section; seats 24 and carries baggage on roof of enclosed section.

MOTORCYCLES

Audiometers for Detecting Noise. Motor Cycle Noises and the Low Audiometer. Engineer, vol. 134, no. 3483, Sept. 29, 1922, pp. 335–336, 4 figs. Describes Low audiometer and gives reproductions of of audiometer records.

Manufacture. An American Motor Cycle Factory. Eng. Production, vol. 5, no. 105, Oct. 5, 1922, pp. 325–331, 19 figs. Plant and methods of the Hendee Mfg. Co., Springfield, Mass.

MOTOR TRUCKS

Weight Reductions. Notes on Motor Trucks, Cornelius T. Myers. Soc. Automotive Engrs. Jl. vol. 11, no. 4, Oct. 1922, pp. 333–341 and (discussion) 341–345, 12 figs. Author outlines reasons why weight reductions are very difficult to effect, as well as possibilities of standardizing axle details. Use of aluminum to effect weight reduction and various advantages claimed for metal wheels are commented upon. Account of series of tests conducted by large coal company to determine relative merits of wood and metal wheels on its trucks. Discusses question of unsprung weight.

N

NICKEL ALLOYS

Non-Ferrous. The Influence of Carbon in Non-Ferrous Nickel Alloys. Metal Industry (Lond.), vol. 21, no. 9, Sept. 1, 1922, p. 195, 2 figs. Points out importance of using only nickel that is as nearly carbon-free as commercial nickel can be. Nickel made by Mond process is said to comply most closely with this condition.

Properties. Nickel and Its Alloys, Paul D. Merica. Am. Mach., vol. 57, nos. 11, 12 and 13, Sept. 14, 21 and 28, 1922, pp. 397–399, 3 figs.; 450–452, 4 figs., and 484–487, 2 figs. Sept. 14: Commercial uses of malleable nickel; how various percentages of nickel affect steel; production of copper-nickel alloys. Sept. 21: Properties and uses of nickel-silver and monel metal; how monel metal should be melted, cast and forged. Sept. 28: Special tools for cutting monel metal; how it should be worked and finished; alloys for electrical and heat-resisting uses.

NON-FERROUS METALS

Superheated Steam Effect on. The Effect of Superheated Steam on Non-Ferrous Metals Used in Locomotives, Henry Fowler. Inst. Metals advance paper for meeting Sept. 20–22, 1922, 4 pp., 2 figs. Experience and practice with regard to chief parts subjected to superheated steam in case of superheated locomotives on Midland Ry. Photomicrographs. See also Engineering, vol. 114, no. 2960, Sept. 22, 1922, p. 374–2 figs.

O

OIL ENGINES

Airless-Injection. Hesselman Airless-Injection for Small and Large Oil Engines. Edvin Lundgren. Motorship, vol. 7, no. 10, Oct. 1922, pp. 766 and 769, 7 figs. Details of method devised by K. J. E. Hesselman on 65-hp. engine.

Production of Workboat Oil-Engines in the East. Motorship, vol. 7, no. 10, Oct. 1922, pp. 764–765, 7 figs. Details of new Wolverine airless-injection four-cycle marine engine.

Manufacture. An American Oil Engine Works. Eng. Production, vol. 5, no. 103, Sept. 21, 1922, pp. 277–282, 18 figs. Equipment and methods of Buffalo Gasoline Motor Co., Buffalo, N. Y.

Solid-Injection. A Swedish Solid Injection Oil Engine. Engineer, vol. 134, no. 3482, Sept. 22, 1922, pp. 290–292, 11 figs. Describes Hesselman engine, special features of which are fuel pump which receives fuel from separate feed pump connected to effective filter; governing and fuel-distributing mechanism, intimately combined with fuel pump; fuel piping; and fuel-injection valve. Translated from article in Swedish publication, by E. Hubendick.

Surface-Ignition. Oil Engines. Southern Engr., vol. 36, no. 6, Feb. 1922, pp. 50–54, 10 figs. Surface-ignition type; classification and field of service; principle, construction and operation. Presented through courtesy of Vacuum Oil Co.

OIL FUEL

Burners. A New Fuel Oil Burner, Arthur Grounds. Oil Eng. & Finance, vol. 2, no. 35, Sept. 9, 1922, pp. 284–285, 3 figs. Describes Meldrum burner for which low steam consumption is claimed. Is modification of steam slot type of burner.

Installation, Singer Building. Fuel Oil Shows Big Saving in Singer Building, Norman King. Power, vol. 56, no. 10, Sept. 5, 1922, pp. 348–352, 6 figs. Two years' operation has shown 34-per cent saving over coal and installation paid for itself in 21 months. Details of construction necessary to meet Building and Fire Departments' regulations.

OILS

Viscosity. Notes on Determination of Absolute Viscosity of Petroleum Oils, W. H. Fulweiler and C. W. Jordan. Jl. Indus. & Eng. Chem., vol. 14, no. 8, Aug. 1922, pp. 723–724. Results of examination of samples of petroleum, animal, and vegetable oils. Paper read before Am. Chem. Soc.

The Change in Viscosity of Oils with the Temperature, Winslow H. Herschel. Jl. Indus. & Eng. Chem., vol. 14, no. 8, Aug. 1922, pp. 715–723, 12 figs. Author claims there is no satisfactory theoretical equation for change of viscosity with temperature. Discusses methods of calculation in use. Paper read before Am. Chem. Soc.

OXY-ACETYLENE CUTTING

Mechanical Control of Torch. Mechanical Control of Oxy-Acetylene Torch, Fred J. Meurer. Can. Machy., vol. 27, no. 26, and vol. 28, no. 2, June 29 and July 13, 1922, pp. 27–28 and 28–29, 12 figs. Cutting metal by this process approaches very closely maximum theoretical efficiency; obtaining any desired shape by means of templates; application of radiograph.

OXY-ACETYLENE WELDING

Cast Iron. Principles of Oxy-acetylene Fusion Welding, Alfred S. Kinsey. Ry. Mech. Engr., vol. 96, no. 10, Oct. 1922, pp. 595–597, 2 figs. Welding cast iron.

Railway Repairs. Application of the Welding Torch to Railroad Repairs. Am. Mach., vol. 57, no. 12, Sept. 21, 1922, pp. 444–448, 17 figs. It is claimed that welding torch reduces cost of repairs; locomotives need not be dismounted; salvage of many small parts possible.

P

PATTERNMAKING

Methods. Firm Demands Pattern Accuracy, H. E. Diller. Foundry, vol. 50, no. 18, Sept. 15, 1922, pp. 743–747, 14 figs. partly on p. 742. Methods, from standpoint of accuracy of workmanship, of Dayton Eng. Laboratories Co., Dayton, O., which manufactures automobile starting and lighting sets.

PISTON RINGS

Iron Melting for. Melts Iron for Piston Rings, B. H. Arnold. Foundry, vol. 50, no. 18, Sept. 15, 1922, pp. 748–751, 6 figs. Oil-fired furnace equipped with pyrometers produces satisfactory metal; oxidation causes hard iron in rings as also does low carbon contents in original charge.

PISTONS

Gas-Engine. Machining Gas Engine Pistons, A. W. Freeman. Am. Mach., vol. 57, no. 15, Oct. 12, 1922, pp. 577–578, 7 figs. Rough turning in automatic machine; trouble due to expansion chuck overcome by chuck of special design; special grinding mandrel.

Light-Metal. Light Metal Piston Competition. Practical Engr., vol. 66, no. 1857, Sept. 28, 1922, p. 201. 16 aluminum and magnesium alloys in form of 32 light-metal pistons were examined in competition promoted by German Government Dept. of Aircraft and Automobiles. Compared with iron, light metals have great heat conductivity.

PLANERS

Drives. Planer Drives, Albert Clegg. Machy. (Lond.), vol. 20, no. 522, Sept. 28, 1922, pp. 777–782, 4 figs. Characteristics of various types, including, ordinary belt-driven planers, clutch and shifting belt planers, direct-coupled reversing-motor, magnetic-clutch, Newton (Derby) planer, and hydraulic drive.

PLATES

Circular, Strength of. On the Strength of a Circular Plate the Thickness of which is not Uniform, Keiichi Aichi. Soc. Mech. Engrs. Tokyo, Japan—Jl., vol. 25, no. 74, June 1922, pp. 61–71, 4 figs. Discusses strength of circular plate whose thickness is function of distance from its center.

Deflection. The Deflection of Continuous Plates and Rectangular Plates with Free Edges (Biegung durchlaufender Platten und rechteckiger Platten mit freien Rändern), A. Nadai. Zeit. des Vereines deutscher Ingeneiure, vol. 66, no. 36, Sept. 9, 1922, pp. 848–849, 3 figs. Deals with girderless ceilings supported by columns in a rectangularly arranged trellis work of points. Discusses deformation and stress of such continuous plates and state of bending in separate points on edge of unsupported rectangular plates.

PNEUMATIC TOOLS

Air-Cleaning Apparatus for. Air Compressing and Cleaning Apparatus. Machy. (Lond.), vol. 20, no. 520, Sept. 14, 1922, p. 739, 2 figs. Describes apparatus, comprising belt-driven compressor, air cooler, oil separator and air receiver for purpose of removing oil and moisture and also solid particles with which free-air supply is usually impregnated.

POWER PLANTS

Equipment. Distinctive European Power Plant Equipment, J. H. Blakey. Power Plant Eng., vol. 26, no. 19, Oct. 1, 1922, pp. 959–961, 5 figs. Describes the Gaillet continuous water purifier; use of corrugated piping; Ruths' steam accumulator; Paradox boiler-tube cleaner.

Harvard Medical School. Power Plant of the Harvard Medical School, Boston, Mass., Charles L. Hubbard. Power, vol. 56, no. 13, Sept. 26, 1922, pp. 482–486, 5 figs. Details of plant supplying light, heat and other services to group of 35 buildings having total space of 13,000,000 cu. ft. Equipment includes eight 3000-sq. ft. Stirling boilers, four of which are oil-burning, 3 d. c. units with total capacity of 725 kw. and several auxiliaries.

Industrial. Power Plant of the Duratex Company Has Many Interesting Features. Power, vol. 56, no. 10, Sept. 5, 1922, pp. 358–362, 7 figs. Plant of 625-kva. has one boiler of 3330 sq. ft. of heating surface and one turbo-generator. Boiler is operated up to 350 per cent of normal rating, is fired by automatic stoker and coal is weighed in weighing larry.

Somersworth, N. H. Power Plant of the Great Falls Manufacturing Co., D. D. Eames. Southern Engr., vol. 37, no. 6, Aug. 1922, pp. 39–42, 4 figs. Turbine units replace reciprocating engines; new boiler plant; electrical energy obtained from three sources, two steam turbines, a hydroelectric plant and water wheels at mill; boiler capacity 3,000 hp. and can be increased to 5,000; turbine capacity 4,500 kw. and can be increased to 10,000.

Sugar Refinery. The Power Plant in a Modern Sugar Refinery, Roger B. Stevens. Power, vol. 56, no. 12, Sept. 19, 1922, pp. 440–445, 4 figs. Details of plant using Corliss engines as prime movers. Advantages and disadvantages of alternating and direct current. Conditions influencing selection of prime movers.

Turbine-Driven. New Turbine Plant, Massachusetts Cotton Mills, Lindale, Ga., Robert W. Van Tassel. Southern Engr., vol. 37, no. 5, July 1922, pp. 35–41, 9 figs. Description of most modern turbine power plants in southern states which supplies power to modernly equipped cotton mill. Tabulated data of equipment giving size, capacity, use and manufacturer.

POWER TRANSMISSION

Mechanical. Mechanical Transmission of Power, Forrest E. Cardullo and Franklin D. Jones. Machy. (N. Y.), vol. 29, no. 2, Oct. 1922, pp. 85–89, 4 figs. Design and installation of shafting and belt and chain transmission.

PRESSES

Hydraulic. Hydraulic Presses, Their Calculation and Construction (Prensas hidráulicas, su cálculo y construcción), Julián Pastor. Anales de la Asociación de Ingenieros del Instituto Católico de Artes e Industrias, vol. 1, no. 2, 1922, pp. 141–145, 5 figs. Construction at least cost consistent with greatest efficiency.

PULVERIZED COAL

Boiler Firing. Pulverized Coal Firing (Le Chauffage au charbon pulvérisé), Sigma. Métallurgie, vol. 54, no. 35, Aug. 31, 1922, pp. 1277–1279, 2 figs. Describes the turbo-pulverizer, its advantages, and power consumed by dry and wet coal in pulverizing.

Pneumatic Conveying. Conveying Fuel in the Form of Dust by Means of Gas (Beförderung staubförmiger Brennstoffe durch Gasleitungen), Wittfeld. Fördertechnik u. Frachtverkehr, vol. 15, no. 19, Sept. 15, 1922, pp. 247–248, 8 figs. Proposes transportation of semi-coke after grinding in gas lines and separating coal dust and gas on arrival at boiler-house.

Utilization. The Utilization of Pulverized Coal, J. Thomas Dovey and George N. Calkins. Can. Inst. Min. & Metallurgy Monthly Bul., no. 125, Sept. 1922, pp. 992–1001. Central distributing systems; oil-burning equipment convertible to burning of powdered coal; principles of use; economies effected; present status of industry.

PUMPING

Solid-Material Transportation by. Transportation of Solid Material by Pumping, Victor J. Milkowski. Cement, Mill & Quarry, vol. 21, no. 6, Sept. 20, 1922, pp. 23–26, 8 figs. Water supply in proportion to amount of solids to be moved; dewatering material at destination; cheap and ample fuel supply a requisite.

PUMPS

Calculation. A Calculation System for Pumps, Terrell Croft. Coal Industry, vol. 5, nos. 8 and 9, Aug and Sept. 1921, pp. 350–353 and 399–402, 16 figs. Aug.: Suction lifts said to be possible under practical conditions. Study of pump heads. Formulas for determining total friction, velocity and measured heads. Sept.: Friction of water in wrought-iron, steel, and cast-iron pipe; frictional resistances in fittings and valves.

PUMPS, CENTRIFUGAL

Curves. Centrifugal Pumps, E. T. Keenan. Southern Engr., vol. 37, no. 6, Aug. 1922, pp. 55–56, 3 figs. Characteristic curves of various types.

Mechanics. Mechanics of Centrifugal Pumps, E. T. Keenan. Southern Engr., vol. 38, no. 2, Oct. 1922, pp. 52–55, 3 figs. Elementary mechanics, principally laws of motion.

Piston vs. Piston and Centrifugal Pumps (Kolbenpumpe und Kreiselpumpe als Wasserhaltungsmaschine), A. P. Mössner. Fördertechnik u. Frachtverkehr, vol. 15, nos. 18 and 19, Sept. 1 and 15, 1922, pp. 235–242 and 254–257, 8 figs. Historic development; electric drive; efficiency of quadruple-action piston and centrifugal pumps of same capacity; superiority of electrically driven centrifugal pumps; comparative tables of efficiency of plunger and centrifugal pumps.

R

RAILWAY ELECTRIFICATION

France. Electrification Work and Projects of the Midi Railway (Travaux et projets d'électrification de la Compagnie des chemins de fer du Midi), Fontaine. Annales des Ponts et Chaussées, vol. 1, no. 3, May-June 1922, pp. 277–295, 3 figs. Hydro-electric power production in Pyrenees; equipment of power stations; program of electrification; change from single-phase to continuous current to eliminate interference with low-tension lines.

South Africa. Electrification of the Glencoe-Maritzburg Section, South African Government Railways, Charles H. Merz. Ry. Gaz., vol. 37, no. 11, Sept. 15, 1922, pp. 332–334. General system of electrification; locomotives; permanent-way equipment substations; transmission lines; power station. (Abstract.) From S. African Railways & Harbours Mag.

RAILWAY MOTOR CARS

Steam-Propelled. Steam-Propelled Unit Railway Motor Car. Ry. Age, vol. 73, no. 16, Oct. 14, 1922, pp. 711–713, 5 figs. Improved power plant with water-tube boiler and oil burner characterize Canadian national car.

Design and Operation of the Unit Railway Steam Car. Ry. Rev., vol. 71, no. 14, Sept. 30, 1922, pp. 433–437, 7 figs. Compact power plant using superheated steam at 800-lb. pressure.

Types. Self Propelled Cars on Steam Railways. Can. Ry. & Mar. World, no. 296, Oct. 1922, pp. 525–527, 6 figs. Details of four self-propelled cars of Can. Nat. Rys. on exhibit at Can. Nat. Exhibition, Toronto, viz., storage-battery car, steam car, and two types of gasoline cars. Results with self-propelled cars in United States. Diesel-electric cars.

RAILWAY OPERATION

Express-Train Service. European Express Train Services. Ry. Gaz., vol. 37, no. 13, Sept. 29, 1922, pp. 391–392 and 400. Detailed analysis of post-war restoration of express-train services is said to give proof that Great Britain occupies first position in speed, frequency and comfort.

Train Control. Automatic Train Control, Frank J. Sprague. Franklin Inst. Jl., vol. 194, no. 2, Aug. 1922, pp. 133–163, 11 figs. Notes on early failures and why greater progress has not been made; general requisites; the Sprague intermittent non-contact system.

Regan Automatic Train Control (Appareil de répétition des signaux et de contrôle automatique des trains système "Regan"), J. G. L. Piveteau. Revue Générale de l'Électricité, vol. 12, no. 6, Aug. 12, 1922, pp. 218–227, 1 fig. Detailed description of system which has been tested on line between Paris and Dieppe.

Robbing Railroading of Some of Its Hazards, Robert G. Skerrett. Compressed Air Mag., vol. 27, no. 10, Oct. 1922, pp. 273–278, 15 figs. Development of automatic train control, and description of the Sprague system.

The Electro-Magnet at the Throttle, Charles W. Burrows. Sci. Am., vol. 127, no. 24, Oct. 1922, p. 242, 2 figs. New type of automatic train control, a system using electromagnets buried in roadway.

The Train Control System of the Great Indian Peninsula Railway. Ry. Gaz., vol. 37, no. 12, Sept. 22, 1922, pp. 363–365, 3 figs. Eight control offices supervise train operation over 1153 mi. of track. Notes on principal books and forms utilized in connection with control working; traffic restrictions.

The Union System of Automatic Train Control, L. V. Lewis. Ry. Rev., vol. 71, no. 12, Sept. 16, 1922, pp. 371–374 and (discussion) 374–375, 6 figs. Describes system developed by Union Switch & Signal Co. to comply with requirements of road conditions. From paper read before Ry. Club in Pittsburgh.

RAILWAY SIGNALING

Alternating-Current, Power Lines. Overload Protection of A. C. Signal Power Lines, Harry M. Jacobs. Ry. Signal Engr., vol. 15, no. 9, Sept. 1922, pp. 345–346, 3 figs. Purpose of overload devices; transformer and substation protection; high-voltage fuses.

Automatic Block. A Scientific Method of Locating Automatic Block Signals for a Railroad of Heavy Traffic, Robert C. Johnson. Am. Ry. Assn., Signal Section, Proc., June 14–16, 1922, pp. A341–A369, 13 figs. See also Ry. Signal Eng., vol. 15, nos. 9 and 10, Sept. and Oct. 1922, pp. 350–353 and 394–398, 13 figs.

Block System. Controlled Manual Block in Hauenstein Tunnel, T. S. Lascelles. Ry. Signal Engr., vol. 15, no. 9, Sept. 1922, pp. 337–340, 8 figs. Describes installation involving wheel-counting principle, instead of track circuit, combined with Siemens-block system, in Hauenstein Base Tunnel, Switzerland, opened in 1916.

I. C. C. Statistics and Tables in Signaling. Ry. Signal Engr., vol. 15, no. 9, Sept. 1922, pp. 354–357, 2 figs. Annual report compiled by Bur. of Safety of Interstate Commerce Commission pertaining to block signals in service and percentage of all roads equipped with this system.

Electric Meters. Theory and Use of Electrical Instruments, L. F. Vieillard. Ry. Signal Engr., vol. 15, no. 10, Oct. 1922, pp. 390–393, 7 figs. Practical explanation of construction and connections of meters used in signaling.

Interlocking. New Electric Interlocking on the D. & H., W. G. Burns. Ry. Signal Engr., vol. 15, no. 8, Aug. 1922, pp. 304–306, 10 figs. Rear home signals, concrete trunking and independent power plant are unusual features.

Single-Track. Single Track Signaling in Australia, F. Raynar Wilson. Ry. Signal Engr., vol. 15, no. 10, Oct. 1922, pp. 379–382, 6 figs. Operation of trains by signal indication considered as safe as token system.

Track Circuits. Direct Current Track Circuits, W. J. Thorrowgood. Am. Ry. Assn. Signal Section, Proc., June 14–16, 1922, pp. A336–A340, 2 tables on supp. plates. Discussion of factors involved in standard of safety for track circuits.

D. C. Track Circuits with Welded Bonds, C. F. Estwick. Ry. Signal Engr., vol. 15, no. 10, Oct. 1922, pp. 383–386, 5 figs. Determination of characteristics of relay to be used on long track circuits when cut sections are eliminated.

Train Order Indications. Train Orders by Signal Indications, A. R. Fugina. Ry. Age, vol. 73, no. 13, Sept. 23, 1922, pp. 553–554, 3 figs. Shows how trains on single or double track can be operated by signals without use of written orders.

RAILWAYS

Japan. The Japanese Railways and Their Operating Problems, H. K. Smith. Ry. Rev., vol. 71, no. 12, Sept. 16, 1922, pp. 365–369, 5 figs. History, physcial characteristics, and character of service; progress toward electrification.

Mexican. Mexican Railways Prepared for Improved Business, Charles W. Foss. Ry. Age, vol. 72, nos. 18 and 19, May 6 and 13, 1922, pp. 1055–1060 and 1119–1121, 12 figs. Roadbed and motive power claimed to be in splendid condition. Shortage of rolling stock a handicap. Improvements now underway. Labor conditions. Relations with U. S. lines.

United States and England. Samuel Rea Compares English and U. S. Railroads. Ry. Rev., vol. 71, no. 15, Oct. 7, 1922, pp. 495–496. Conditions affecting railroads in United States and those of Great Britain. Finds progress abroad in regrouping and believes English carriers must make sacrifices as here. From Phila. Public Ledger.

RAPID TRANSIT

Chicago. Chicago Transportation Experience. Elec. Ry. Jl., vol. 60, no. 13, Sept. 23, 1922. Contains following articles: Carrying a Billion Passengers a Year in Chicago, pp. 419–424, 10 figs. Dealing with the Labor Problem, Britton I. Budd, pp. 425–427. How Car Design Has Progressed on Chicago's Rapid Transit Lines, H. A. Johnson, pp. 427–430, 4 figs. Maintaining Chicago "L" Structure, G. M. Anderson, pp. 430–431. Signaling Trains on Chicago Elevated Railroads, J. W. Stephenson, p. 431. How "L" Track is Built to Handle 900,000 Cars a Year, H. P. Savage, p. 432, 1 fig. Utility Insurance, Williston Fish, pp. 433–434. Heating and Ventilating Chicago Street Cars, Charles Gordon, pp. 435–439, 7 figs. Developing Chicago's Street Cars, Wray T. Thorn, pp. 440–444, 3 figs. Experience with Chicago Track, Charles S. Holcomb, pp. 445–452, 10 figs. Development of Unified Power Supply and Distribution Systems in Chicago, Ralph H. Rice, pp. 455–461, 5 figs. Requirements Imposed in Designing North Shore Passenger Cars, H. A. Otis, pp. 470–472, 6 figs. Using Direct Suspension Trolley in High-Speed Train Service, Clifford Huttleston, pp. 473–476, 9 figs. Chicago's Traffic Problem, R. F. Kelker, Jr., pp. 481–484, 10 figs.

Chicago Transportation Experience. Elec. Ry. Jl., vol. 60, no. 14, Sept. 30, 1922. Contains following articles: Developing Chicago's Street Cars, Wray T. Thorn, pp. 499–505, 14 figs. Heating and Ventilating Chicago Street Cars, Charles Gordon, pp. 505–509, 12 figs. How Stores Are Accounted for on Chicago Elevated Railroads, E. E. Kretschmer, pp. 510–514, 3 figs. Automatic Door Control on Latest Chicago Safety Cars, pp. 514–516, 3 figs.

REFRACTORIES

Compressive Strength. Volume Constancy and Compressive Strength of Refractory Lining of Boilers and Furnaces (Raumbeständigkeit und Druckfestigkeit der feuerfesten Auskleidung von Dampfkessel- und Feuerungsanlagen), W. Ritter. Feuerungstechnik, vol. 10, no. 23, Sept. 1, 1922, pp. 259–261. Methods and results of tests. See also Wärme- u. Kälte-Technik, vol. 24, no. 16, Aug. 15, 1922, pp. 185–187.

Foundry. Foundry Refractories, H. Winterton. Foundry Trade Jl., vol. 26, no. 318, Sept. 21, 1922, pp. 236–238. Notes on siliceous refractories; question of sands; coal dust; defects caused by lime in sand; grist; blackings; graphitic facings.

REFRIGERANTS

Sulphurous Anhydride. New System of Manufacturing Liquid Sulphurous Anhydride (Nuovo sistema di fabbricazione della anidride solforosa liquida nelle regioni sud-americane), H. J. Paoli. Giornale di Chimica Industriale ed Applicata, vol. 4, no. 8, Aug. 1922, pp. 349–352, 3 figs. Methods used by Sulfurica Co. in Argentina; operation of plant.

REFRIGERATING MACHINES

Air. Air as Refrigerating Agent (Sur l'emploi de l'air comme agent frigorifique), Maurice Leblanc. Révue Universelle des Mines, vol. 14, no. 3, Aug. 1, 1922, pp. 165–200, 16 figs. Describes new cold-air refrigerating machine which from tests proves to be as economical as an ammonia machine. See also Nature (Paris), no. 2529, Sept. 23, 1922, pp. 203–208, 7 figs.

Ethyl-Chloride. Ethyl Chloride Refrigeration Charles H. Herter. Refrig. World, vol. 57, no. 9, Sept. 1922, pp. 13–16 and 32, 3 figs. Theoretical heat balance of ethyl chloride refrigerating machines; results of actual tests; horsepower per ton in small machines.

ROLLING MILLS

Electrically Driven. Electric Blooming Mill Drive, S. N. Roberts. Elec. Jl., vol. 19, no. 9, Sept. 1922, pp. 356–362, 12 figs. Deals with drive of Atlantic Steel Co.'s blooming mill.

The New Electric Rolling Mills of the Hatfield Steel Works, at Sheffield (Les nouveaux laminoirs électriques des aciéries Hadfield, à Sheffield). Génie Civil, vol. 81, no. 13, Sept. 23, 1922, pp. 269–273, 5 figs. Equipment of East Hecla Works; production of manganese steels; the blooming train; electric power equipment; etc.

Processes. The Mechanical Working of Iron and Steel, Walter Buckley. Eng. Jl. (Eng. Inst. Can.), vol. 5, no. 10, Oct. 1922, pp. 499–504, 10 figs. Outline of modern rolling-mill practice, describing processes in various types of mills.

Strip and Hoop. Combined Strip and Hoop Mill of the Whitehead Iron and Steel Company, Limited. Iron & Coal Trades Rev., vol. 105, no. 2847, Sept. 22, 1922, pp. 417–418, 15 figs. on pp. 433–436. Details of continuous mill combining main features of the Acme and the Morgan continuous skelp mill. First of its type to be built in the world.

New Cold Rolled Strip Steel Plant. Iron Age, vol. 110, no. 15, Oct. 12, 1922, pp. 920–922, 5 figs. Finishing stands driven independently of roughing stands; unusual uniformity obtained in annealing ovens of special design. Details of new rolling mills of Wallingford Steel Co., Conn.

Universal Plate. Universal Mill at the Redcar Works of Messrs. Dorman, Long and Company, Limited. Iron & Coal Trades Rev., vol. 105, no. 2846, Sept. 15, pp. 377–378, 14 figs. on pp. 393–396. Describes mill of two-high reversing type with two vertical rolls on each side of horizontal rolls, which is capable of rolling universal plates 42 in. wide down to 11 in. wide.

RUBBER

Stress-Strain Tests. Electrical Records of Rubber Stress-Strain Data, C. J. Burkley. India Rubber World, vol. 67, no. 1, Oct. 1, 1922, pp. 24–25, 3 figs. How charts are made; mechanical and electrical features of apparatus; making test records.

S

SAFETY

Codes. Preparation of Safety Codes Under the Auspices of the American Engineering Standards Committee, Morton C. Lloyd. Monthly Labor Rev., vol. 15, no. 3, Sept. 1922, pp. 1–8, 1 fig. It is shown that American Engineering Standards Committee with coöperation of Safety Code Correlating Committee, furnishes machinery for formulation of safety codes in manner which will insure thorough consideration of viewpoint of various interests concerned with safety codes.

SAND, MOLDING

Grain and Bond. An Investigation on the Factors Influencing the Grain and Bond in Moulding Sands, C. W. H. Holmes. Foundry Trade Jl., vol. 26, nos. 318 and 320, Sept. 21 and Oct. 5, 1922, pp. 245–246 and 279–282, 3 figs. Investigation undertaken with view to estimating quantitatively effect upon essential properties of sand of various processes to which molding sands are subjected.

Moulding Sands, C. W. H. Holmes. Engineering, vol. 114, no. 2962, Oct. 6, 1922, pp. 443–446, 6 figs. Investigation on factors influencing grain and bond in molding sands. (Abstract.) Paper read before Iron & Steel Inst.

Properties and Use. Some Notes on Moulding Sands, J. H. Watson. Foundry Trade Jl., vol. 26, no. 317, Sept. 14, 1922, pp. 211–216, 15 figs. Early post-war experiences; use and abuse of good sand; origin of sand and typical composition, essential properties, refractoriness, venting qualities, strength of bond, grain size.

Screen Tests. Analyzes Sand Screen Tests, H. A. Schwartz. Foundry, vol. 50, no. 18, Sept. 15, 1922, pp. 752–756, 7 figs. Mathematical investigations indicate effect of grains of different shapes and sizes on perviousness of molding sand; method of testing; conclusions. Paper read before Am. Foundrymen's Assn.

Testing. The Testing of Moulding Sands, Ernest J. Davis. Metal Industry (Lond.), vol. 21, nos. 10 and 11, Sept. 8 and 15, 1922, pp. 219–221 and 243–247, 6 figs. Describes how laboratory testing may be carried out. Notes on chemical, mechanical and mineral analysis; bonding strength, mechanical strength of sand molds and cores; thermal conductivity, permeability, porosity and microscopic examination.

SCREW THREADS

Milling. The Milling of Screws and Other Problems in the Theory of Screw-Threads, H. H. Jeffcott. Instn. Mech. Engrs. Proc., vol. 1, no. 3, 1922, pp. 515–528 and (discussion) 529–562, 19 figs. Account of problems of interest to manufacturer and metrologist.

Normal Thickness of Worm-Gear. The Normal Thickness of a Worm Thread, E. A. Limming. Machy. (Lond.), vol. 20, no. 519, Sept. 7, 1922, pp. 707–708, 1 fig. Geometrical consideration involved in finding true normal thickness.

Tolerances. Interchangeable Threaded Work. Engineering, vol. 114, nos. 2959 and 2960, Sept. 15 and 22, 1922, pp. 320–321 and 352–354, 12 figs. Brief survey of practical and theoretical requirements of

screw threads and consideration of problms of tolerances. Presents tables of effective diameter tolerances recommended by Alfred Herbert, Ltd., for all screw threads to English measurements having thread angle of 55 or 60 deg., and for all metric threads having thread angle of 53.8 to 60 deg.; and recommended for British Assn. screw threads.

SEAPLANES

German Giant. Flying Boat and Pontoon Airplane, (Flugboot und Schwimmerflugzeug). Motorwagen vol. 25, no. 22, Aug. 10, 1922, pp. 421–423, 2 figs. Describes new type of giant seaplane which is a combination of flying boat and pontoon airplane with Junker wings and built-in engines. Characteristics: Span, 60 m.; engines, four 700-hp.; speed, 170 km. per hr.; passengers, 60.

Types. Characteristics of the Aircraft Entered in the Curtiss Marine Flying Trophy Race. Aviation, vol. 13, no. 14, Oct. 2, 1922, pp. 413–415, 4 figs. Details of seaplanes of float and boat types.

SHAFTS

Bending Moments. Bending Moments in Pins or Shafts Determined Graphically, A. M. Winslow. Eng. News-Rec., vol. 89, no. 14, Oct. 5, 1922, pp. 568–569, 3 figs. Effect of forces in different planes expressed by composite moment diagram. Maximum movement found by inspection.

SHEARING MACHINES

Plate. Plate Shearing Machines. Eng. Progress, vol. 3, no. 9, Sept. 1922, pp. 203–205, 7 figs. Describes plate-shearing machines with and without flywheel.

SLOTTING MACHINES

Horizontal. Horizontal Slotting Machine with Electric Drive, G. Schleisinger. Eng. Progress, vol. 3, no. 9, Sept. 1922, pp. 206–208, 6 figs. Results of tests conducted during a number of years for purpose of improving horizontal shotting machine with function wheel drive.

SOLIDS

Electron Theory of. An Electron Theory of Solids, J. J. Thomson. Franklin Inst. Jl., vol. 194, no. 3, Sept. 1922, pp. 281–289, 4 figs. Points out that electronic theory of constitution of atom leads quite simply and directly to theory of solids which, as far as it has been tested, agrees remarkably well with facts.

Failure Due to Stress. Laws of Failure of Solid Bodies Due to Stress, Chidô Sunatani. Soc. Mech. Engrs., Tokyo, Japan—Jl., vol. 25, no. 74, June 1922, pp. 1–37, 50 figs. Investigation of laws by which elastic limit and ultimate failure of solid body under certain state of stress may be determined.

SPECIFIC HEAT

Low Temperatures. Investigations of Specific Heat at Low Temperatures, (Untersuchungen über die spezifische Wärme bei tiefen Temperaturen), Franz Simon. Annalen der Physik, vol. 68, no. 3, Aug. 3, 1922, pp. 241–280, 6 figs. Describes certain improvements in Nernst-Schwers apparatus which greatly increases accuracy of measurements. The true specific heat of quartz glass, Lindemann glass, mercury, ammonium chloride, glycerine and other substances is measured from temperature of pumped-out liquid hydrogen to room temperature.

SPRINGS

Automobile. Automobile Springs (Automobilwagenfedern), W. Schlachter. Motorwagen, vol. 25, nos. 21 and 25, July 31 and Sept. 10, 1922, pp. 395–398 and 481–484, 10 figs. General principles underlying design; calculations.

Leaf. Leaf Springs (Ressorts spéciaux a lames superposées), C. Reynal. Arts et Métiers, vol. 75, no. 22, July 1922, pp. 210–212, 3 figs. Leaf springs for vehicles; calculation and distribution of load.

STANDARDIZATION

France. Permanent Standardization Committee (Commission permanente de Standardisation), Sigma. Métallurgie, vol. 54, no. 21, May 25, 1922, pp. 749–750. This committee has decided on public hearings. Standardization of dimensions; choice of units; etc.

Permanent Standardization Committee (Commission permanente de Standardisation), Sigma. Métallurgie, vol. 54, no. 36, Sept. 7, 1922, pp. 1311–1313. Plans recently submitted to public discussion on standardization of copper and aluminum buzz bars for switchboards; aluminum wire and cables; and specifications for supplying platinum, platinum-copper, platinum-iridium and platinum-chloride.

Mechanical Construction. Standardization of Dimensions in Mechanical Construction (Sur la normalisation des dimensions des elements de la construction mécanique), F. Bayle. Révue Générale de l'Électricité, vol. 12, no. 10, Sept. 9, 1922, pp. 345–352, 4 figs. Arithmetic and geometric units; practical measures which should be given preference; importance of adoption of standard measures of length.

STANDARDS

German N. D. I. Reports. Report of the German Industry Committee on Standards (Normenausschuss der Deutschen Industrie), Maschinenbau, vol. 1, no. 10, Aug. 26, 1922, pp. 665–684, 29 figs. Proposals of Board of Directors for T-head bolts; abbreviated symbols for screw threads; mathematical symbols; T-slots; test gages (unit holes and shafts); etc. Proposed standards for tangent slots, trapezoidal threads, flat keys, hollow keys, gib-headed keys, etc.

Uniform Designations for Calculating Strength in Building Construction (Einheitliche Bezeichnungen für die Festigkeitsberechnungen von Ingenieurbauwerken), Schaper. Zentralblatt der Bauverwaltung, vol. 42, no. 77, Sept. 23, 1922, pp. 464–467. Gives list of standard abbreviations and symbols for mathematics, measures, time, mechanical and statical expressions, and discusses standardization generally.

STEAM

High-Pressure. High-Pressure Steam-Heating Lines, Edgar Buckingham. Mech. Eng., vol. 44, no. 10, Oct. 1922, pp. 641–642. Effect of throttling through reducing valve or steam motor; economy of generating steam at high pressure and transmitting it through small line with large line drop.

STEAM ENGINES

Rolling-Mill Reciprocating. Rolling Mill Engine of 25,000 Horse Power. Power House, vol. 15, no. 19, Oct. 5, 1922, pp. 19–20, 2 figs. Built on marine lines for hardest kind of land service; working at full power it reverses four times per min.; three-cylinder but not compound.

25,000 Hp. Engine Built in England. Power, vol. 56, no. 13, Sept. 26, 1922, pp. 491–492, 1 fig. Describes reciprocating engine built for Carge Fleet rolling mills, one of largest in England.

Uniflow. Another Corliss Engine Firm Building Unaflow Engines. Power, vol. 56, no. 16, Oct. 17, 1922, pp. 600–601, 5 figs. Uniflow engines being built by Murray Iron Works Co. in powers ranging from 75 to 650 i.hp., of side-crank bored guide horizontal design.

Valve Gears. Engines at Baltimore Refinery Have Unusual Valve Gear. Power, vol. 56, no. 13, Sept. 26, 1922, pp. 498–499, 5 figs. Twin engines 26 by 32 in., operating at 135 r.p.m., direct connected to 1250-kw. d.c. generator.

Steam-Engine Distributing and Expansion Valves and Valve-Gear and Valve-Actuating Arrangements Therefore. Abridgments of Specifications, class 122(ii), period 1909–15, 1922, 256 pp. Patents for inventions.

STEAM POWER PLANTS

Fuel Economy. Fuel Economy in Steam Power Plants. John B. C. Kershaw. Beama, vol. 11, nos. 2, 3, and 4, Aug., Sept. and Oct. 1922, pp. 538–545, 6 figs., 617–625, 7 figs. and 671–681, 11 figs: Aug.: Present-day methods of burning fuel and their defects. Sept.: Improved methods of burning fuel. Oct.: Utilization of waste heat from steam boilers.

STEEL

Alloy. See ALLOY STEELS.

Chromium. See CHROMIUM STEEL.

Elastic Limit. Elastic Limit and Permanent Deformation of Steels by Multiple Forces (Limite élastique et deformation permanente des aciers dans le cas de forces multiples), L. Malaval. Technique Moderne, vol. 14, nos. 7 and 8, July and Aug. 1922, pp. 289–296 and 345–350, 21 figs. Elastic limit for metals subjected simultaneously to traction and compression; resistance to rupture of cylindrical tubes; effect of simple and compound loads. Bibliography.

Flow at Low Red Heat. Experiments on the Flow of Steels at a Low Red Heat with a Note on the Scaling of Heated Steels, J. H. S. Dickenson. Iron & Coal Trades Rev., vol. 105, no. 2845, Sept. 8, 1922, pp. 327–331, 15 figs. (Abstract.) Paper read before Iron & Steel Inst. See also Engineering, vol. 114, nos. 2959 and 2960, Sept. 15 and 22, 1922 pp. 326–329 and 378–379, 21 figs.

Lag. On the Dimunition of Lag at Arl through Deformation, J. H. Whiteley. Engineering, vol. 114, no. 2961, Sept. 29, 1922, p. 416, 6 figs. Evidence is given that when steel, in metastable region at Arl point is worked, lag is markedly diminished. Paper read before Iron & Steel Inst.

Manganese. See MANGANESE STEEL.

Testing. Rapid Determination of Elongation and Resistance to Impact of Steels by Doubling Over a Notched Bar (Détermination, rapide de l'allongement et de la résistance au choc des aciers, par pliage d'un barreau entaillé), L. Jannin. Bul. de la Société d'Encouragement pour l'Industrie Nationale, vol. 134, no. 7, July 1922, pp. 646–656, 7 figs. Results of tests.

Tool. See TOOL STEEL.

STEEL CASTINGS

Alloy, Manufacture of. Alloy Castings from Electric Furnaces, Larry J. Barton. Iron Age, vol. 110, no. 13, Sept. 28, 1922, pp. 784–786, 1 fig. Describes manufacture, properties and heat treatment of nickel, chromium and chrome-nickel steel. Practice of Los Angeles Foundry Co.

Production. Production of Steel Castings, F. Darley. Foundry Trade Jl., vol. 26, nos. 316 and 317, Sept. 7 and 14, 1922, pp. 199–202 and 225–226, 7 figs. Sept. 7: Scope of steel castings; production essentials; turbine wheels and cylinders; making large base plate; molding spur wheel. Sept. 14: Stainless steel castings, engine-wheel centers; piping, clinking, blow holes and annealing of castings.

STEEL, HEAT TREATMENT OF

Hardening. The Scientific Fundamentals of Steel Hardening (Die wissenschaftlichen Grundlagen der Stahlhärtung), Otto Keune. Maschinenbau, vol. 1, no. 10, Aug. 26, 1922, pp. 645–649, 8 figs. Discusses relations between carbon content and strength properties; forms in which carbon is present in steel; appearance of fracture; microscopic investigation of hardened and unhardened steel; theory of steel hardening.

Lead-Pot Furnace. Heat Treating in Lead, R. B. Schenck. Am. Soc. for Steel Treating, Trans., vol. 2, no. 12, Sept. 1922, pp. 1203–1212. It is concluded that greatest argument for lead-pot furnace is high quality of treated product resulting from uniform and accurate temperatures.

Mass, Influence of. Influence of Mass in Heat Treatment, E. J. Janitzky. Iron Age, vol. 110, no. 13, Sept. 28, 1922, pp. 788–790, 4 figs. Role of special elements, nickel, chromium and molybdenum, in counteracting effect of size. Experimental data on sections 0.5 to 3 in. in diameter.

Nickel-Chromium. Heat Treating Changes Volume, Leslie Aitchison and G. R. Woodvine. Iron Trade Rev., vol. 71, no. 14, Oct. 5, 1922, pp. 915–918, 5 figs. Experiments conducted on nickel-chromium steels indicate expansions and contraction is related directly to temperature alterations. Summary shows results of subjecting metal to various conditions. (Abstract.) Paper presented before Iron & Steel Inst.

Tool Steel. The Heat Treatment of Tool Steel (Ueber Wärmebehandlung von Werkzeugstählen), H. Baier. Maschinenbau, vol. 1, no. 10, Aug. 26, 1922, pp. 650–653, 2 figs. Deals with treatment of ordinary tool steel and different special steels in forging, annealing, hardening and tempering practice.

STEEL, HIGH-SPEED

Lathe Breakdown Tests. Lathe Breakdown Tests of Some Modern High Speed Tool Steels, H. J. French and Jerome Strauss. Am. Soc. for Steel Treating, Trans., vol. 2, no. 12, Sept. 1922, pp. 1125–1154, 19 figs. Comparisons of performance of tool steels in so-called lathe breakdown tests, in which endurance of tools is measured under definite working conditions.

Manufacture. Practical Notes on the Manufacture and Treatment of High-Speed Steel, H. K. Ogilvie. Iron & Coal Trades Rev., vol. 105, no. 2845, Sept. 8, 1922, pp. 331–333. Deals chiefly with manufacture in basic-lined electric furnace. (Abridgment.) Paper read before Iron & Steel Inst. See also Engineer, vol. 134, no. 3481, Sept. 15, 1922, pp. 282–283.

STEEL MANUFACTURE

Electric Furnaces. Electric Steel Production of the World, Edwin F. Cone. Iron Age, vol. 110, no. 11, Sept. 14, 1922, pp. 653–654. Record of leading countries from 1913 to 1921. Post-war and present conditions. Pig iron from electric furnaces.

STEEL WORKS

England. The Devonshire Ironworks. Engineer, vol. 134, no. 3480, Sept. 8, 1922, p. 242, 3 figs., partly on p. 246. Consists in the main of up-to-date blast-furnace plant, one of largest coke-oven plants in United Kingdom, and extensive pipe foundries for manufacture of cast-iron pipe; also comprises large by-product recovery plant, and chemical plant for manufacture of sulphuric and nitric acids, and other chemicals.

Holland. Construction of the Royal Dutch Steel Works at Velsen, Holland [La construction des Aciéries royales néerlandaises à Velsen (Hollande)], Génie Civil, vol. 81, no. 6, Aug. 5, 1922, pp. 138–139, 2 figs. Work in connection with providing access; construction of works themselves; buildings for personnel; etc.

Material Testing. Material Testing in Mass Production (Materialprüfung in der Massenfertigung), Hermann Obermüller. Werkstattstechnik, vol. 16, no. 17, Sept. 1, 1922, pp. 506–508. Points out importance of material testing in iron and steel works and duties of material-testing department in plant for mass production.

Three-Shift vs. Two-Shift. Three Shifts vs. Two, in Steel, Bradley Stoughton. Iron Trade Rev., vol. 71, nos. 12, 13 and 14, Sept. 21, 28 and Oct. 5, 1922, pp. 791–795, 856–860 and 923–929, 1 fig. Practicability of changing work-period system in industry investigated from technical viewpoint. Report in favor of shorter hours as adopted by executive board of Am. Eng. Council. See also (abstract) in Iron Age, vol. 110, no. 11, Sept. 14, 1922, pp. 657–658 and 689.

STOKERS

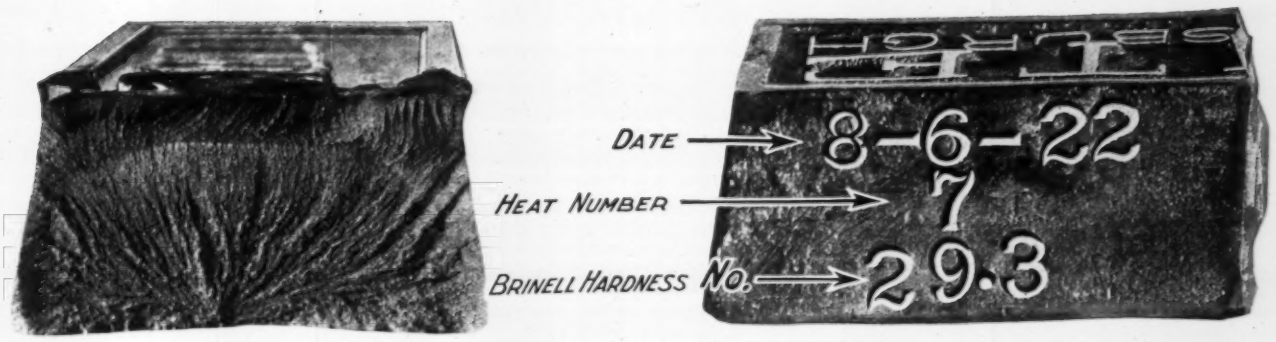
Chain-Grate. Forced-Draft Traveling Grates with Combined Chain Grate (Unterwind-Wanderroste mit kombinierter Rostkette), H. Pradel. Wärme, vol. 45, no. 30, Aug. 4, 1922, pp. 367–368, 5 figs. Describes combined sectional and nest chain grates built by Berlin-Anhalt Machine Corp., Dessau, which are said to combine advantages of both types.

Mechanical. Mechanical Stokers and Stoking, Walter N. Polakov. Management Eng., vol. 2, no. 6, June 1922, pp. 325–330 and vol. 3, nos. 1, 2, 3 and 4, July, Aug., Sept. and Oct. 1922, pp. 29–36, 73–80, 171–179 and 233–241, 50 figs. June: Origin and development. July: Process of combustion. Aug.: Chain-grate stokers. Sept.: Overfeed stokers. Oct.: Underfeed stokers.

Underfeed. Detroit Edison Co. Has Superstoker, E. E. Dubry Power, vol. 56, no. 14, Oct. 3, 1922, pp. 536–538, 5 figs. 13-retort underfeed stoker having total grate area of 470 sq. ft. replaces double stoker setting under Stirling type-W boiler of 23,654-sq. ft. effective heating surface, and makes possible big reduction in number of overhead bunkers and coal-conveying equipment.

STRESSES

Cylinder Walls. The Stress of a Thin Cylinder Wall Taking Deformation into Consideration (Die Beanspruchung einer dünnen Zylinderwand bei Berücksichtigung der Formänderung), Josef Krebitz. Eisenbau, vol. 13, nos. 6 and 7, June 20 and July 25, 1922, pp. 119–124 and 143–149, 6 figs. Investigation of deformation of cylinder wall which is free from bending stress.



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TANKS

Industrial. Getting the Most out of Industrial Tanks, Charles L. Hubbard. Factory, vol. 29, no. 4, Oct. 1922, pp. 398–400 and 457–458, 6 figs. Suggestions for selection of right tank.

TAPS

Production Operations. Operations in Tap Production, C. F. Henley. Machy. (Lond.), vol. 20, no. 520, Sept. 14, 1922, pp. 733–734, 3 figs. With particular reference to thread milling, thread-milling hobs, and heat treatment.

TESTING MACHINES

Railway Material. Deflection Testing of Locomotive Axles. Engineer, vol. 134, no. 3480, Sept. 8, 1922, pp. 279–280, 3 figs. Describes universal 100-ton testing machine, constructed by A. J. Amsler & Co., Schaffhausen, Switzerland, for performing acceptance tests on railway material, such as hooks, chains, axles, couplings, etc.

TEXTILE MILLS

Electric Drive. Electric Power in Textile Mills. Beama, vol. 11, no. 4, Oct. 1922, pp. 694–697, 4 figs. Information extracted principally from pamphlet on power in the textile mill, published by Metropolitan-Vickers Co.

The Electric Drive in the Textile Industry, William A. A. Burgess. Beama, vol. 11, no. 2, Aug. 1922, pp. 554–558, 1 fig. Notes on position of electric drive in textile industry, and type of drive.

THERMODYNAMICS

Heterogeneous Equilibria, Application to. The Application of Thermodynamics to Heterogeneous Equilibria, George W. Morey. Franklin Inst. Jl., vol. 194, no. 4, Oct. 1922, pp. 425–484, 11 figs. By detailed application of described equation (equation 97) problems of heterogeneous equilibria may be solved completely if entropy and volume changes are known in their entirety, and it is possible to predict behavior of system when subjected to changes in pressure, temperature, and composition.

Molecular. Molecular Thermodynamics, Bernard A. M. Cavanagh. Lond., Edinburgh, & Dublin Philosophical Mag. & Jl., of Sci., vol. 44, no. 261, Sept. 1922, pp. 610–640. Analysis of problem of "solvation of solutes" to which is attached discussion of results.

TIDAL POWER

Utilization. Theory of River Tides and Their Utilization (Sur la théorie des marées fluviales et ses applications), Charles Ribiere. Annales des Ponts et Chaussées, vol. 1, no. 3, May-June 1922, pp. 266–276. Mathematical investigation showing that substantial modifications are necessary in current formulas used.

Utilization of Tidal Power (Sur l'utilisation de l'énergie des marées), A. Defour. Révue Générale de l'Électricité, vol. 11, no. 9, Mar. 4, 1922, pp. 313–322, 8 figs. Discusses the Maire, Claude, Etat and Defour cycles and compares their efficiency.

TIME STUDY

Standards in. Establishing Standards in Time Study, Philip Bernstein. Indus. Management, vol. 64, no. 4, Oct. 1922, pp. 243–249, 4 figs. Definite procedure with specific illustrations from woodworking practice.

TIRES, RUBBER

Rolling Resistance. Rolling Resistance of Rubber Tires, E. H. Lockwood. India Rubber World, vol. 67, no. 1, Oct. 1, 1922, pp. 13–15, 4 figs. Notes on rear-wheel dynamometer; measuring tire resistance; solid-tire tests; cord and fabric-tire tests; loss of power in tires.

Truck, Pneumatic. Temperatures of Pneumatic Truck-Tires, F. O. Ellenwood. Soc. Automotive Engrs. Jl., vol. 11, no. 2, Aug. 1922, pp. 129–138, 16 figs. Investigation conducted at plant of Goodyear Tire & Rubber Co. to determine best means of measuring tire temperatures; temperature effect of inflation pressure, load, long runs, frequency of stops, and sizes of rim and tire; temperature of various designs of tire; and suitable means of reducing large-tire temperatures.

TOOL STEEL

Graphitization. Graphitization in a Carbon Tool Steel, Henry S. Rawdon and Samuel Epstein. Chem. & Met. Eng., vol. 27, no. 13, Sept. 27, 1922, pp. 650–651, 8 figs. Examination of type of black fracture occasionally occurring in annealed carbon-tool-steel bars.

Machinability. The Effect of Structure upon the Machining of Tool Steel, J. V. Emmons. Am. Soc. for Steel Treating, Trans., vol. 2, no. 12, Sept. 1922, pp. 1100–1110 and 1212, 20 figs. Discusses effect of hardness and structure of tool steel upon its machinability. Machining operations considered are turning, milling, drilling, reaming, thread cutting, swaging, wire drawing, punching and shearing. Conclusions as to most favorable structures for various machining processes.

TOOLS

Diamond, for Motor Building. Using Diamond Tools in Motor Building, G. T. Linting. Am. Mach., vol. 57, no. 12, Sept. 21, 1922, pp. 437–439, 8 figs. Information concerning accuracy, interchangeability and long life obtained with diamond tools in aluminum, bronze and cast iron. Experiences of N. Y., N. H. & H. R. R.

TRACTORS

Caterpillar. Making Tracks for Caterpillars, Howard L. McLean. West. Machy. World, vol. 13, no. 9, Sept. 1922, pp. 311–312, 5 figs. Notes on methods and machines used in Holt factory at Stockton, Cal., for machining and assembling flexible steel tracks.

Road-Building Machinery. Internal-Combustion-Engine Power for Road-Grading Machinery, C. O. Wold. Soc. Automotive Engrs. Jl., vol. 11, no. 4, Oct. 1922, pp. 323–326 and (discussion) 326–327, 4 figs. Deals with large versus small tractors and most suitable type of tractor; engine requirements; use of multiple-unit road machinery behind one power unit; combination tractor and grader units; general utilization of power units; power requirements of concrete-road construction.

Suction-Gas. The Suction Gas Tractor. Engineer, vol. 134, no. 3482, Sept. 22, 1922, p. 306. Considerations relating to use of suction gas producers on tractors and their design and working.

TUBING

Steel. Corrugated Steel Tubing for High-Pressure Liquids (Tubes ondulés en acier pour fluides à haute pression), R. Joessel. Génie Civil, vol. 81, no. 6, Aug. 5, 1922, pp. 130–133, 9 figs. Construction, application and advantages; gives greater elasticity lengthwise; has greater resistance to pressures and is easily adjustable to any profile.

U

UNEMPLOYMENT

Insurance. Unemployment Insurance in Theory and Practice. Nat. Indus. Conference Board, Research Report, no. 51, June 1922, 127 pp. Outline of theory and main questions involved in such insurance; analysis of development of and practical experience with this theory, principally in Europe; survey of theory and problems as related to situation in United States.

Insurance and Employment Exchanges. Work of the Employment and Insurance Department of the British Ministry of Labor, T. W. Phillips. U. S. Bur. of Labor Statistics Bul., no. 311, Aug. 1922, pp. 38–59. Notes on establishment of employment exchanges; employment-exchange procedure and statistics; decasualization of dock labor; unemployment insurance; effect of war; local employment committees; extension of unemployment insurance in 1920; effect of industrial depression on insurance scheme; provision of work for unemployed; etc.

Prevention. Prevention of Unemployment, U. S. Bur. of Labor Statistics Bul., no. 311, Aug. 1922, pp. 60–78. Contains following articles: Measurement of Unemployment—The Heed for Additional Information, F. S. Deibler. Contribution of Vocational Guidance to the Prevention of Unemployment, Helen T. Woolley. Reviving Private Industry through Public Works, Otto T. Mallery.

Problems of. The New Emphasis in the Problem of Reducing Unemployment, H. Feldman. Taylor Soc. Bul., vol. 7, no. 5, Oct. 1922, pp. 176–182, 1 fig. Brief review of remedies proposed in recent years. American attitude toward problem. Experiences of the Hills Bros. Co., manufacturers of dates.

V

VENTILATION

Air-Duct Calculation. How to Figure Rectangular Air Duct Sizes Quickly, W. L. Durand. Am. Soc. Heating & Vent. Engrs. Jl., vol. 28, no. 7, Oct. 1922, pp. 719–721, 1 fig. Presents table prepared by author that will give correct-size rectangular air duct with minimum of effort which means materially simplifying calculations.

Automatic Ventilators. Comparative Tests of Automatic Ventilators, J. P. Calderwood, A. J. Mack and C. J. Bradley. Am. Soc. Heating & Vent. Engrs. Jl., vol. 28, no. 5, July 1922, pp. 505–513, 6 figs. Tests conducted in engineering experiment station of Kansas State Agricultural College to determine efficiency of various types.

VOCATIONAL TRAINING

Foundrymen. The Training of Foundrymen, A. A. Liardet. Foundry Trade Jl., vol. 26, no. 309, July 20, 1922, pp. 54–58. Writer recommends scheme for training of foundrymen.

W

WAGES

American Manufacturing Industries. Wages and Hours in American Manufacturing Industries, July 1914-January 1922. Nat. Indus. Conference Board, Research Report, no. 52, July 1922, 235 pp., 112 figs. Sets forth reliable data portraying movement of hourly and weekly earnings, hours of operation and workers' hours as well as changes in employment, from pre-war period to date.

Incentive Systems. Effect of Labor Setting on Labor Costs, William O. Lichtner. Indus. Management, vol. 64, no. 3, Sept. 1922, pp. 169–172. It is claimed that managers have taken incentive out of wage-inventive systems by unintelligent rate cutting.

Piece-Rate Methods. The Piece-Rate Wage Method in the Workshops of the German State Railways (Das Gedingeverfahren in den Werkstätten der Deutschen Reichsbahn), Hans A. Martens. Zeit des Vereines deutscher Ingenieure, vol. 66, no. 38, Sept. 23, 1922, pp. 916–920. Discusses principles of this system as practiced during last two years in German railway shops, and measures for improvement with special regard to time studies and details of wage system.

Putting Production Incentive into Pay Envelopes, Samuel Theaker. Indus. Management, vol. 64, no. 4, Oct. 1922, pp. 216–220, 3 figs. Explains how good points of piecework can be utilized while removing at the same time the disfavor with which it is regarded.

Systems. A Survey of Wage Systems, Paul P. Gemmill. Indus. Management, vol. 64, no. 4, Oct. 1922, pp. 207–208. Compiled from experience of 50 plants.

WASTE HEAT

Utilization. Blast Furnace Waste Heat Utilized, Hubert Hermanns. Blast Furnace & Steel Plant, vol. 10, no. 10, Oct. 1922, pp. 531–534, 9 figs. Points out that by employing waste-heat utilizers in conjunction with engines large part of waste heat may be recovered. Account of German experiences.

WASTE PREVENTION

Industrial. A Further Consideration of the Report of the Committee on Elimination of Waste in Industry, Thomas W. Mitchell. Taylor Soc. Bul., vol. 7, no. 5, Oct. 1922, pp. 198–204.

WATER

Specific Heat. The Ratio of the Calorie at 73° to That at 20°, Arnold Romberg. Am. Acad. Arts & Sci. Proc., vol. 57, no. 15, June 1922, pp. 377–378, 10 figs. Describes experiment designed as crucial test of correctness of temperature-variation curve of specific heat of water.

WATER POWER

St. Lawrence Region. Water Power Situation in the St. Lawrence Region, J. T. Johnston. Can. Engr., vol. 43, no. 12, Sept. 19, 1922, pp. 359–361, 2 figs. Relation to St. Lawrence Waterway development; 6,077,427 undeveloped horsepower within 300 miles of Long Sault exclusive of undeveloped St. Lawrence Power; probable demand for power.

Snake River. Snake River as a Source of Power, W. G. Hoyt. Elec. World, vol. 80, no. 16, Oct. 14, 1922, pp. 811–813, 3 figs. Undeveloped power sites total 1,510,000 hp., with existing flow available for 90 per cent of time.

WEIRS

Herschel Type. An Investigation of the Herschel Type of Weir, Richard H. Morris and Albert J. R. Houston. Mech. Eng., vol. 44, no. 10, Oct. 1922, pp. 651–654, 8 figs. Results of tests made to determine effect of various modifications in construction on action of improved type of weir designed by Clemens Herschel for gaging in open channels.

WELDING

Electric-Railway Practice. Welding as Practiced by Electric Railways. Elec. Ry. Jl., vol. 60, no. 15, Oct. 7, 1922, pp. 567–568. Symposium of papers forming basis of discussion at joint meeting of Am. Welding Soc. and Am. Elec. Ry. Eng. Assn. Fields of several varieties of welding were outlined.

Tube. Contraction in Tube Welding, Marcel Piette. Acetylene Jl., vol. 24, no. 3, Sept. 1922, pp. 120–121, 5 figs. Distortion can be avoided by expanding pieces in opposite sense before welding. Translated from Revue de la Soudure Autogène, with additions.

[See also ELECTRIC WELDING; ELECTRIC WELDING, ARC; OXY-ACETYLENE WELDING.]

WIND PRESSURE

Calculation. Wind Velocity and Wind Pressure (Windgeschwindigkeit und Winddruck), Karl Buchegger Bauingenieur, vol. 3, no. 16, Aug. 31, 1922, pp. 491–495, 1 fig. Develops formulas and gives diagram based on experimental results from which main factors are readily available.

WOOD

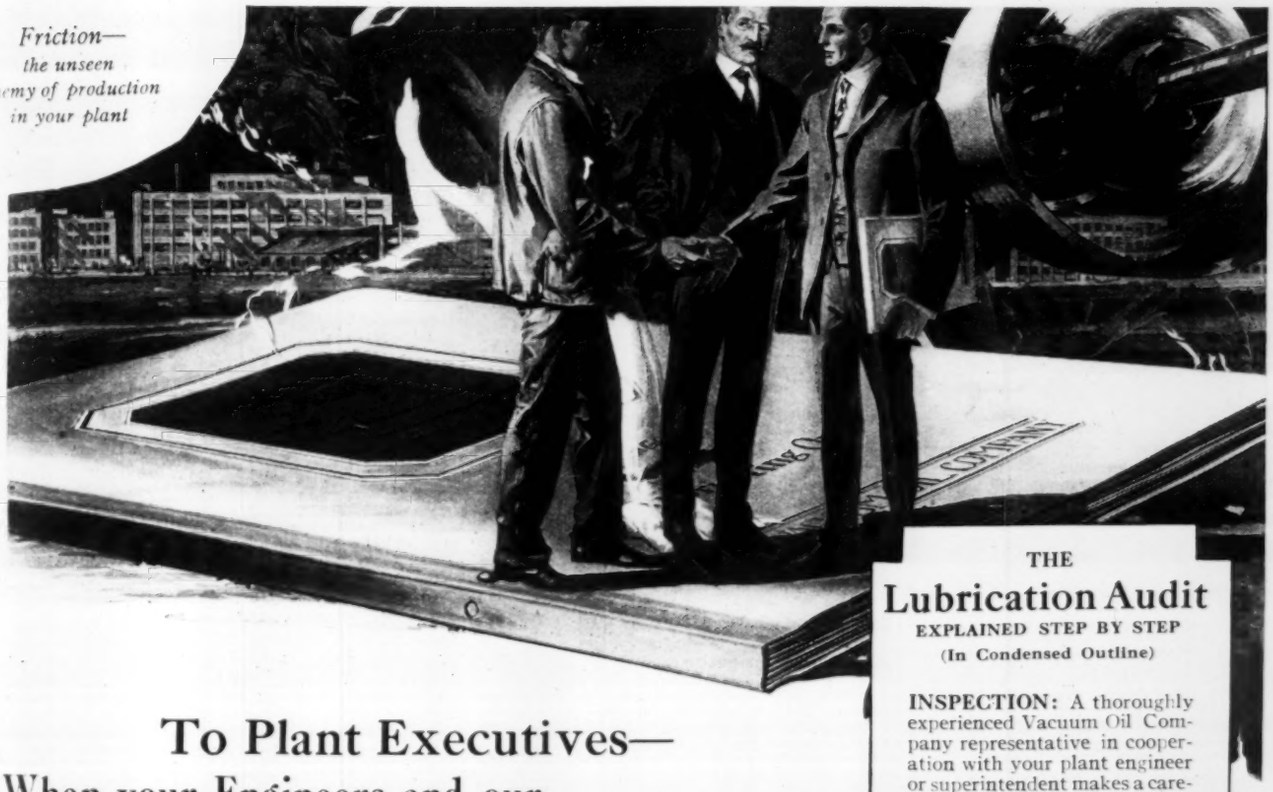
Heating Value of American Woods. The Calorific Value of American Woods, S. W. Parr and C. N. Davidson. Jl. Indus. & Eng. Chem., vol. 14, no. 10, Oct. 1922, pp. 935–936, 3 figs. Results of experiments to determine "end point."

Testing Machine. Amsler Machine for Static and Dynamic Testing of Wood (Machine Amsler pour les éssais statiques et dynamiques des bois). Bul. Technique de la Suisse Romande, vol. 48, no. 17, Aug. 19, 1922, pp. 197–201, 9 figs. Built by A. J. Amsler & Co. at Schaffhausen, for bending, compression, impact and other tests; construction and operation.

WORKMEN'S COMPENSATION

Social Insurance and. Workmen's Compensation and Social Insurance. Monthly Labor Rev., vol. 15, nos. 1 and 3, July and Sept. 1922, pp. 142–146 and 196–201. July: Recent reports. National health and unemployment insurance in Great Britain. Sept.: Comparison of workmen's compensation insurance and administration. Recent compensation reports. Experience under Danish invalidity insurance law. Accident insurance in Norwegian fishing industry, 1920.

Friction—
the unseen enemy of production in your plant



To Plant Executives—
When your Engineers and our Representatives put their heads together

WHEN one of our representatives comes to your plant, he comes—not as a lubrication theorist,—not as a meddler in your plant,—not as a mere oil salesman.

He comes as a practical man with a practical knowledge of machinery and a specialized knowledge of oil. He comes to co-operate.

Your man contributes his knowledge of the operating conditions and lubrication problems in your plant. Our man contributes from the Vacuum Oil Company's wide knowledge of lubrication gained through many years of study and experience all over the world.

Thus, when your man and our man get together, they meet on common ground. They discuss the common problem of Lubrication from the standpoint of such practical matters as coal waste, power losses, preventable friction, overheated bearings, oil waste, repair bills, etc.

The sale of a barrel or so of oil is the last subject brought up.

If you are not already having the benefit of the Vacuum Oil Company service, we shall be glad to make a Lubrication Audit of your plant. See details in column at right.

We are making Lubrication Audits every day in every country in every kind of plant. We make no charge for this co-operative service. Please feel free to call for it at any time.

But as "any time" is likely to be "no time"—why not today?

GARGOYLE

Lubricating Oils

A grade for each type of service

THE Lubrication Audit

EXPLAINED STEP BY STEP
(In Condensed Outline)

INSPECTION: A thoroughly experienced Vacuum Oil Company representative in cooperation with your plant engineer or superintendent makes a careful survey and record of your mechanical equipment and operating conditions.

RECOMMENDATIONS: We later specify, in a written report, the correct oil and correct application of the oil for the efficient and economical operation of each engine and machine.

This report is based on:—

(1) The inspection of the machines in your plant.

(2) Your operating conditions.

(3) Our 56 years of lubricating experience with all types of mechanical equipment under all kinds of operating conditions throughout the world.

(4) Our outstanding experience in manufacturing oils for every lubricating need.

CHECKING: If, following our recommendations in this audit, you install our oils, periodical calls will be made to check up the continuance of the desired results.

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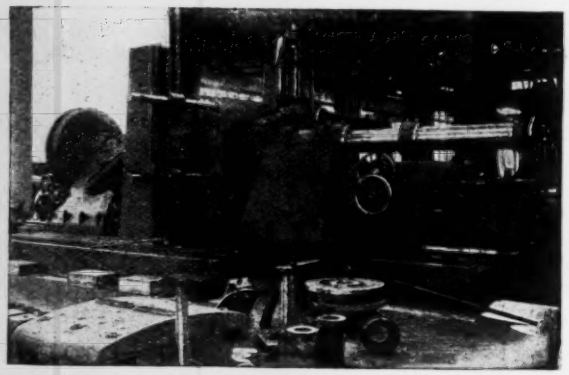
VACUUM OIL COMPANY

HAMILTON ENGINES



A Special Cylinder Boring Machine which permits the cylinders, barrel and ports of an engine to be bored at one setting, thus insuring perfect alignment

Hamilton Engines Save Money

THE time to avoid losses, both *in* and *because* of your power plant, is when you buy your power equipment. That is why consulting and operating engineers recommend dependable HAMILTON Heavy Duty Engines and Machinery.

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The soundness of this policy has been proven by the years of steady, economical service HAMILTON engines have rendered The Carnegie Steel Company, The Pennsylvania Hotel, The Ford Motor Company, and other corporations which are leaders in their industry. What Hamilton engineers and heavy duty engines and machinery have done for them, they can do for you.

The Hooven, Owens, Rentschler Co.

Hamilton Engines and Machinery

HAMILTON, OHIO

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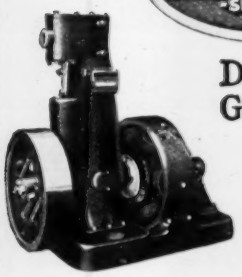

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A combination of superior design, materials and workmanship—an ideal formulated on thirty years' experience in the manufacturing and testing of Vertical Steam Engines. Catalog No. 301.

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ATTRACTIVE PRICES

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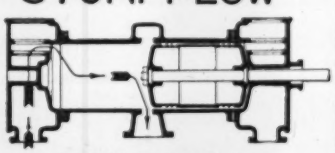

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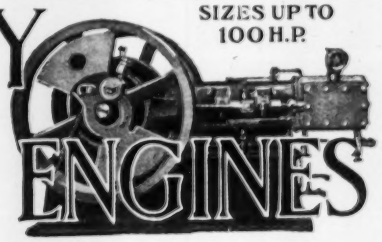
SIZES UP TO 100 H.P.



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Good Engines only

Troy Engines are steady, dependable power producers. They deliver all the power, all the time that you must have it; and perform noiselessly and almost without vibration.

They have many good features—our latest catalog tells about them—send for it.

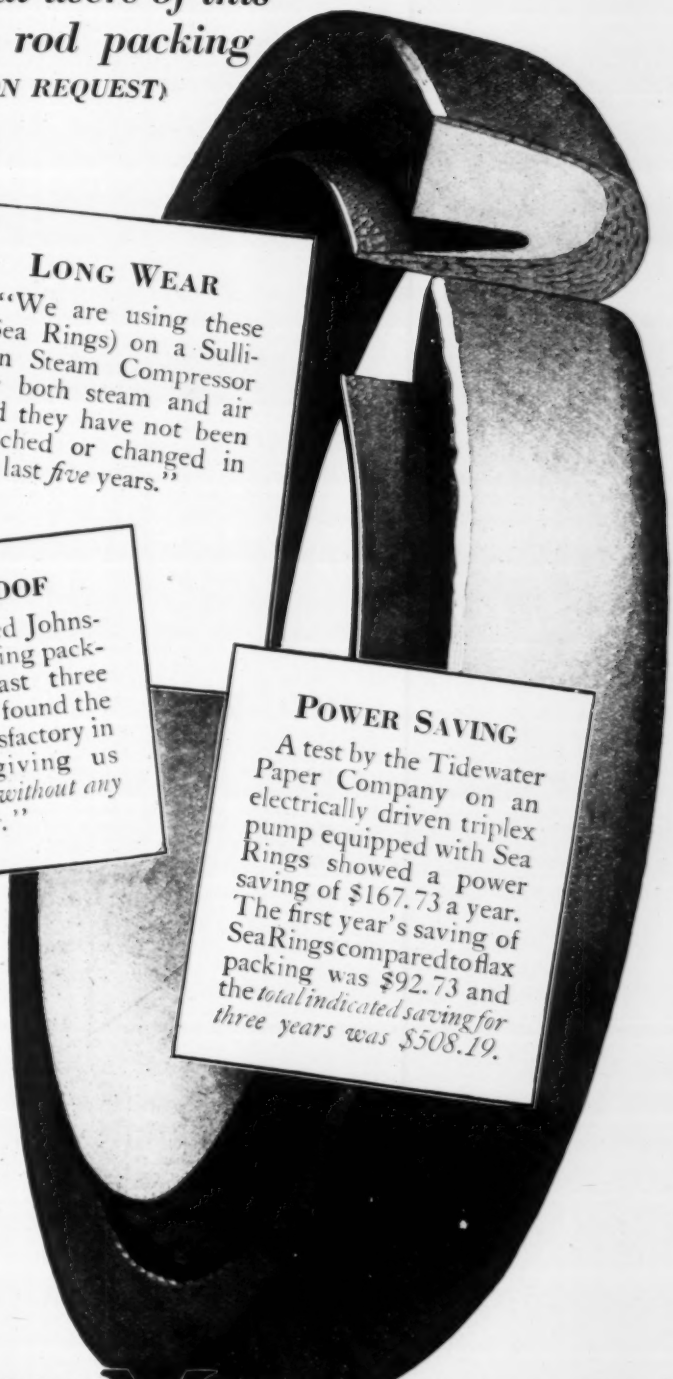
See our data in 1922 A.S.M.E. Condensed Catalogues

TROY ENGINE COMPANY
TROY, PA.

4 Sea Ring Economies

—told by actual users of this remarkable rod packing

(NAMES ON REQUEST)



NO ADJUSTMENT

"We are pleased to recommend this wonderful packing for air service as we have *never touched the stuffing boxes* since installing the packing three years ago."

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"We are using these (Sea Rings) on a Sullivan Steam Compressor for both steam and air and they have not been touched or changed in the last *five* years."

LEAK PROOF

"We have used Johns-Manville Sea Ring packing for the last three years and have found the same to be satisfactory in every way, giving us better service *without any leaks whatever.*"

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A test by the Tidewater Paper Company on an electrically driven triplex pump equipped with Sea Rings showed a power saving of $167.73 a year. The first year's saving of Sea Rings compared to flax packing was $92.73 and the *total indicated saving for three years was $508.19.*

The Sea Ring is a modern, scientifically constructed rod and plunger packing. Cylinder pressure trapped in the U-shaped section expands the packing with just enough force to prevent leakage. This automatic action cuts friction and means reduced wear, power saved, and economy.

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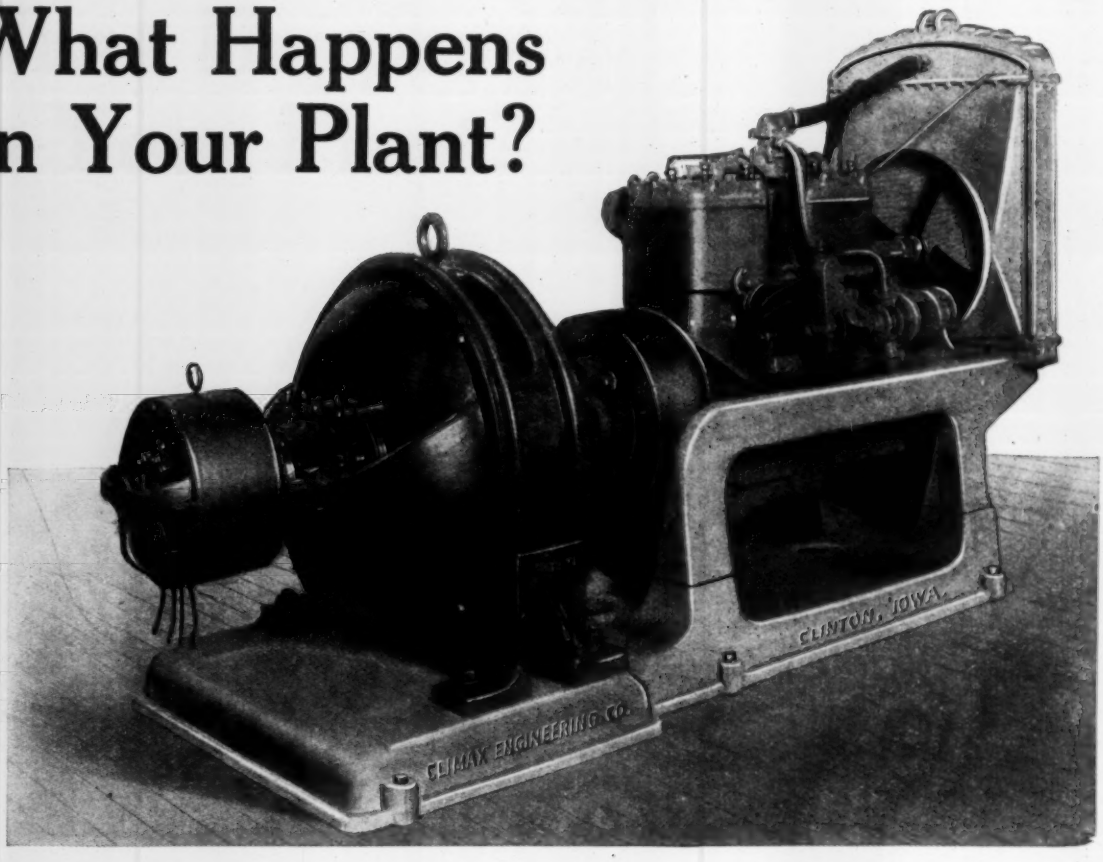
What Happens In Your Plant?



When the power is shut off in your plant what happens? A Climax power unit will bring immediate relief in any emergency by providing all the current you need for lights, motors or electric arc cutting and welding.

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"THE TRUSTWORTHY ENGINE"

Moderate Speed—Heavy Duty
30 to 70 H. P.—Kerosene or Gasoline

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Manufacturers of Internal Combustion Engines for Automotive and Industrial Power Purposes.

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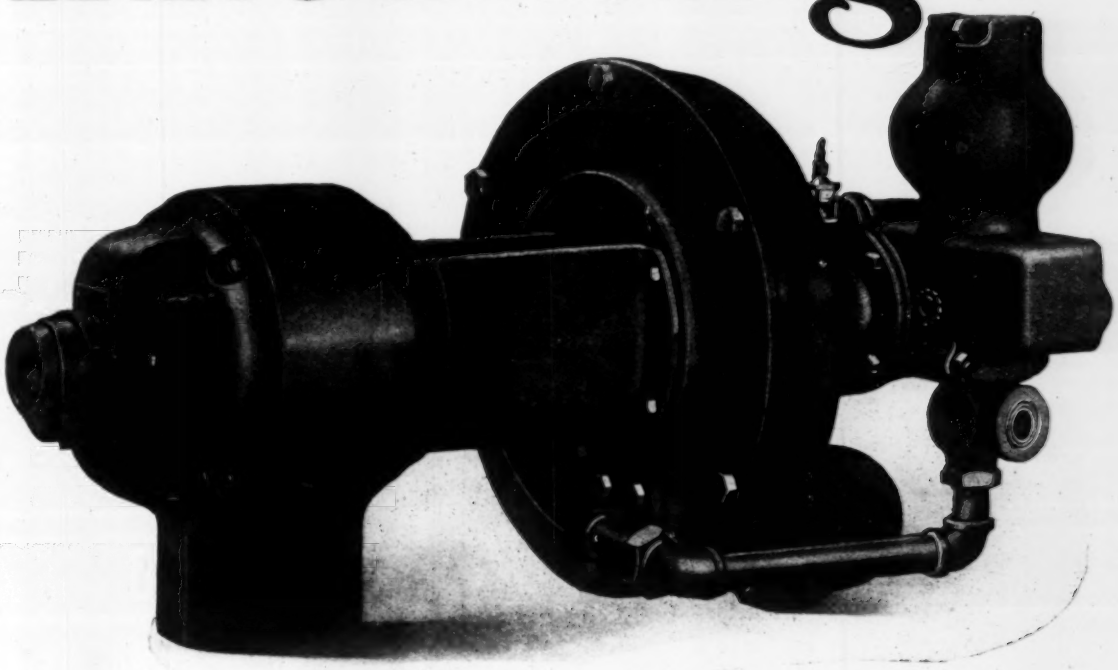

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THE NEW KERR STEAM TURBINE GENERATOR SET, 500 TO 2000 WATT CAPACITY

Newest of Kerr Turbines, worthy to take its place with the thousands that have made and are making turbine history the country over.

Designed for installation and use under the many conditions where common labor and "oil can maintenance" are all that can be expected.

Provides a flexible, economical, reliable source of electric light and power wherever steam is available—and that is most everywhere. It is a real turbine for real work—ask our Engineers how it can be put to work for you.

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"Ridgway" Considered the Standard

THE wide application of electrical power to industrial purposes, creates a need for transforming devices of almost endless variety. Ridgway motor-generator sets are designed to meet conditions in particular installations.

That is why "Ridgway" is considered the standard by which others are judged in many lines of industry.

When you see equipment bearing the name "Ridgway" you may be sure it was designed for that particular installation—and will deliver unfailing power economically.

Skilled engineers assemble and test Ridgway equipment before it is shipped. The purchaser need never worry about his power equipment after it is installed.

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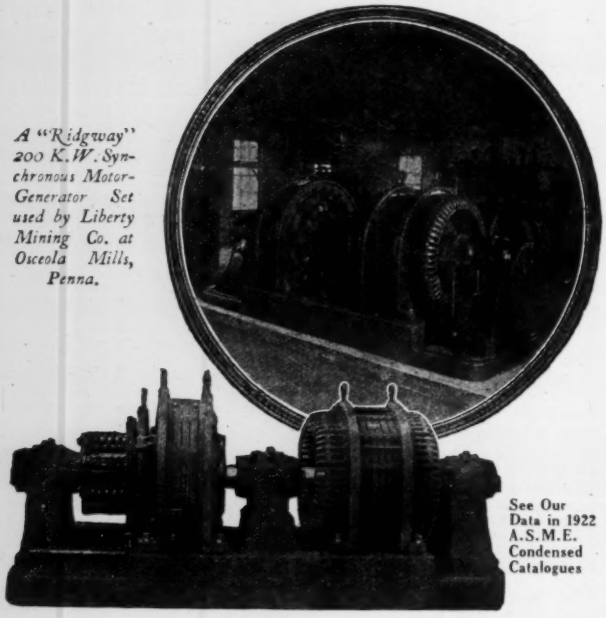

A "Ridgway" 200 K.W. Synchronous Motor-Generator Set used by Liberty Mining Co. at Osceola Mills, Penna.

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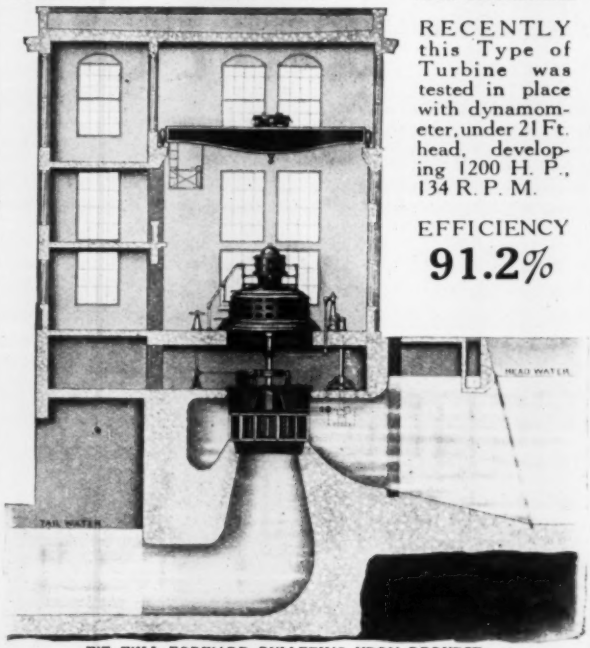
RIDGWAY

To Produce Unfailing Power Economically ***POWER UNITS***

LEFFEL TURBINE WATER WHEELS

HIGH SPEEDS HIGH POWERS HIGH EFFICIENCIES



RECENTLY this Type of Turbine was tested in place with dynamometer, under 21 Ft. head, developing 1200 H. P., 134 R. P. M.

EFFICIENCY **91.2%**

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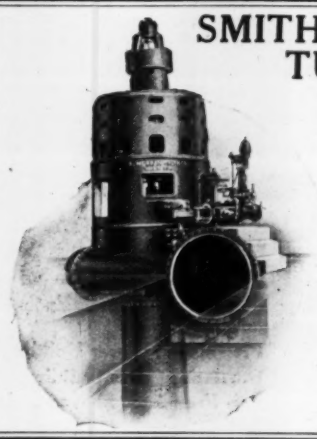

Accompanying view shows single vertical shaft turbine unit with direct connected generator and self-contained governor.

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S. MORGAN SMITH CO.

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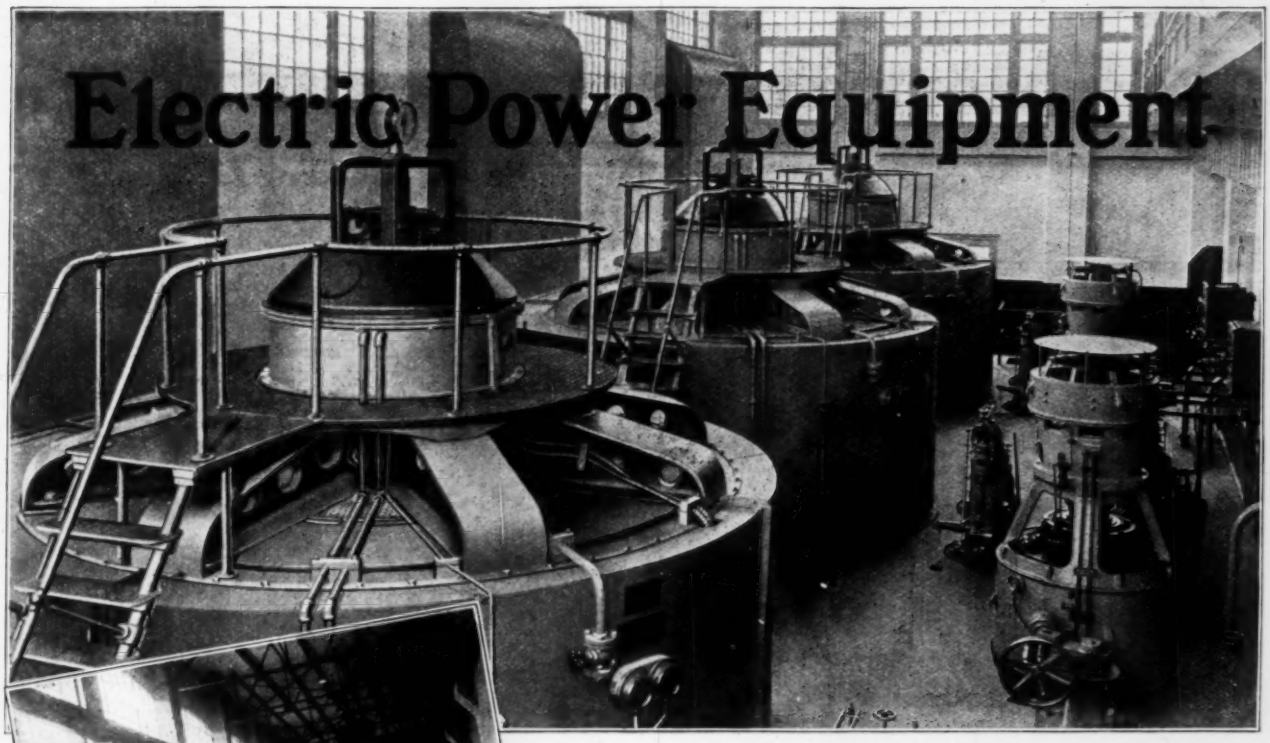

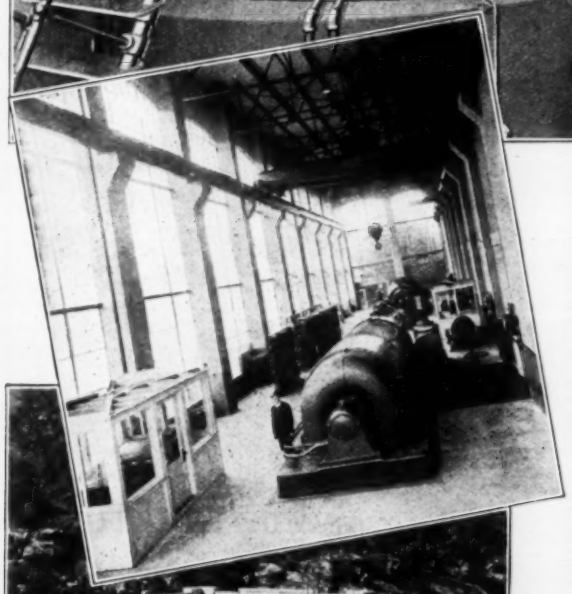

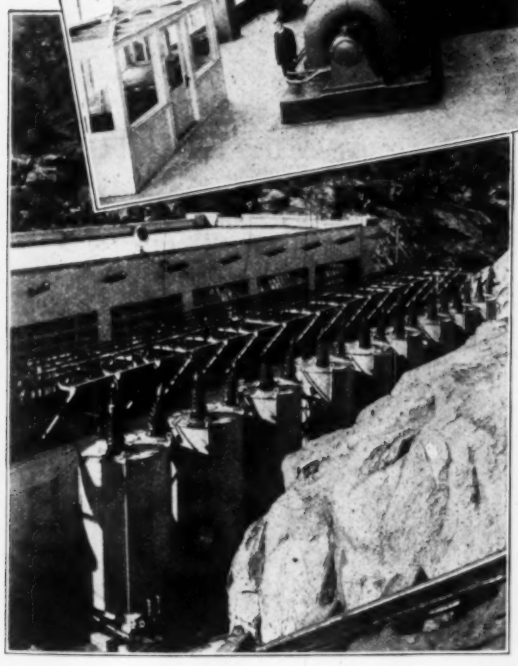

For the power plant, complete equipment "from prime mover to switchboard" is built by the Allis-Chalmers organization. This includes all types of prime movers—steam turbines, hydraulic turbines, steam, gas and oil engines, together with complete electrical equipment. Condensers of all types, pumps, air compressors and many other auxiliaries are also supplied. Allis-Chalmers equipment is used in plants of all sizes, and includes some of the largest power units ever built.

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See pages 20, 21 and 398 in the 1922 A.S.M.E. Condensed Catalogues

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The Wm. Cramp & Sons Ship & Engine Building Co.

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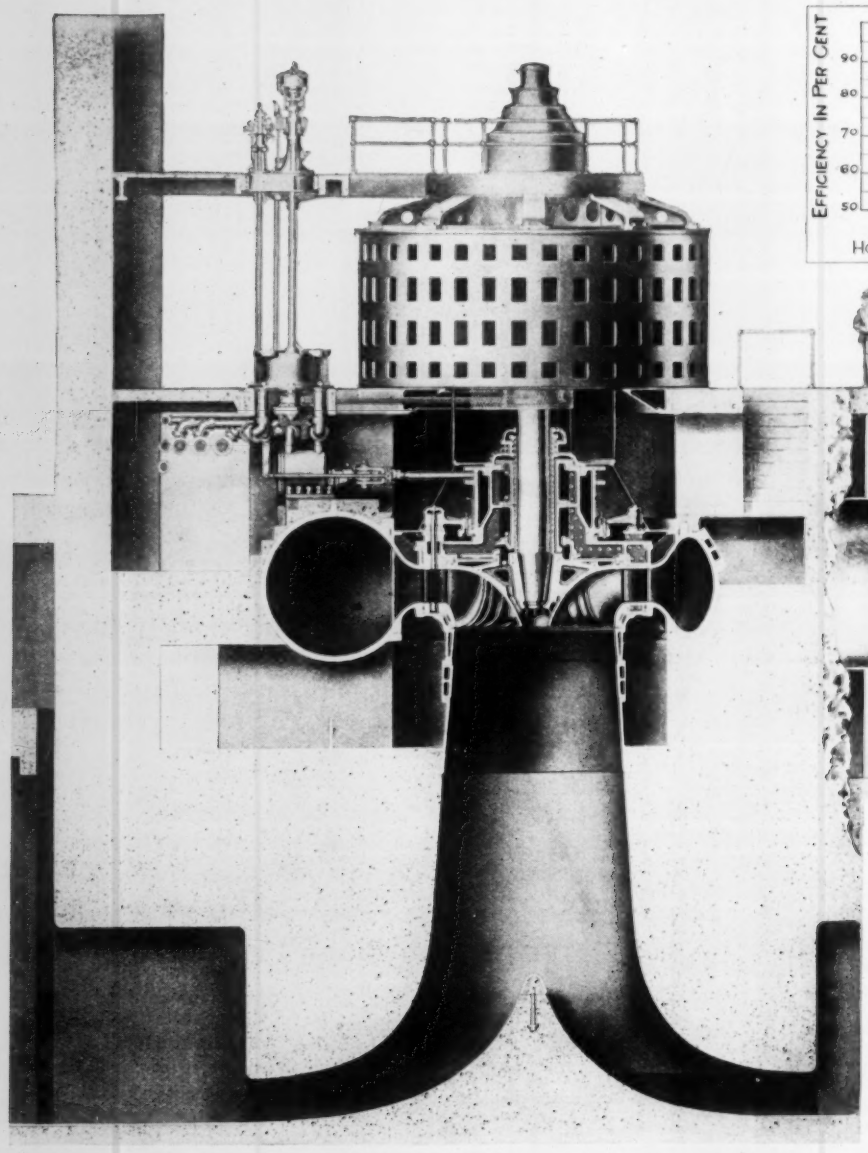

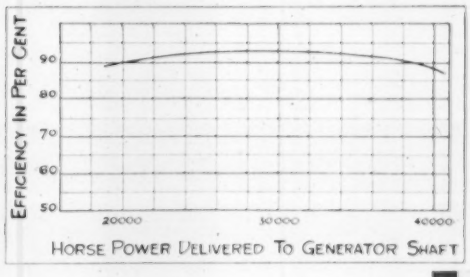

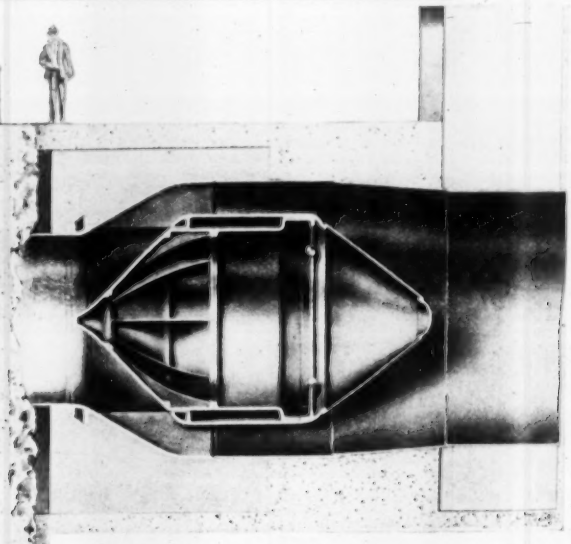

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Pneumatic Lubricating System
Spreading Draft Tube
Automatic Governor Control
Labyrinth Runner Seals
Johnson Penstock Valve
Double Floating Lever Governors

Two 37,500 HP. Turbines

Built in 1919 for Plant No. 3-B of

The Niagara Falls Power Co.

As shown by above insert of official test these turbines developed the highest efficiency ever attained over a wide range of power.

Two 70,000 HP., I. P. Morris Turbines

and

Three Johnson Hydraulic Penstock Valves

Now Under Construction for Installation in Plant No. 3-C of

THE NIAGARA FALLS POWER CO.

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Special Features included in design of these units:—

Pneumatic Lubricating System
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Automatic Governor Control
Offset Operating Gear
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Adjustable Lignum vitae Guide Bearing
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Thirteen 10,000 H.P. and two 1000 H.P. turbines have previously been installed in the above Power Company's Plant No. 3-A. The first of these units was installed in 1907 and the service rendered by this plant is demonstrative of the dependability of I. P. MORRIS HYDRAULIC TURBINE MACHINERY.

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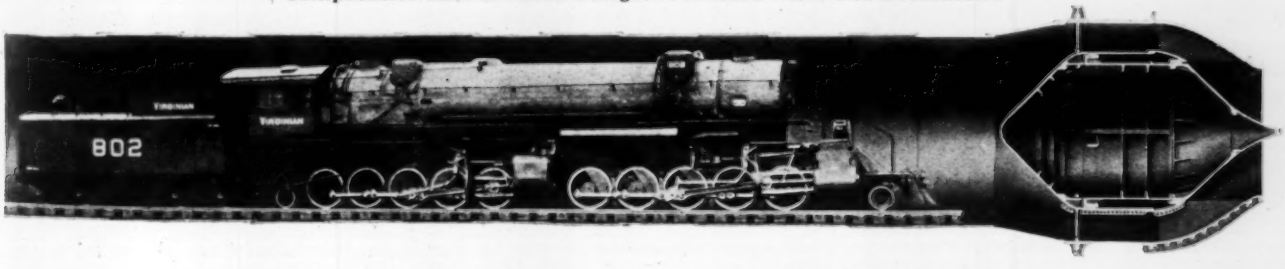
Comparative sizes of world's largest Penstock Valve and Locomotive



Inlet Diameter of Valve 21 ft.-0 in. Outlet Diameter 14 ft.-0 in.

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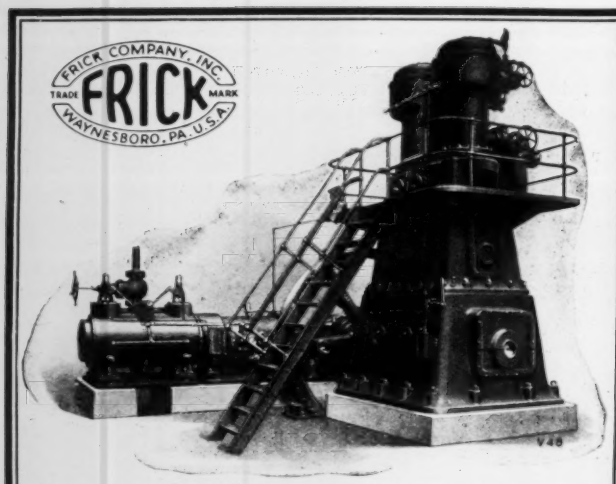
The Pelton Water Wheel Co., San Francisco and New York

Dominion Engineering Works, Ltd., Montreal, Canadian Licensees.



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——the most efficient type built——

with either direct connected Uniflow Steam Engine or Synchronous Motor and a Frick Raw Water Ice Plant assure you quality ice at lowest cost.

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THE NORWALK IRON WORKS CO.
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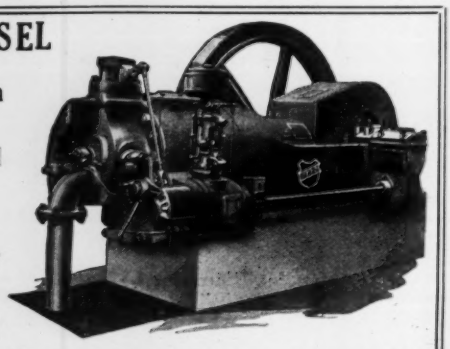
Crude & Fuel Oil Engines
24 to 140 H.P.

Gas Producer Power Plants

Engines for all Fuels



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Standard for 50 Years Philadelphia, Pa.

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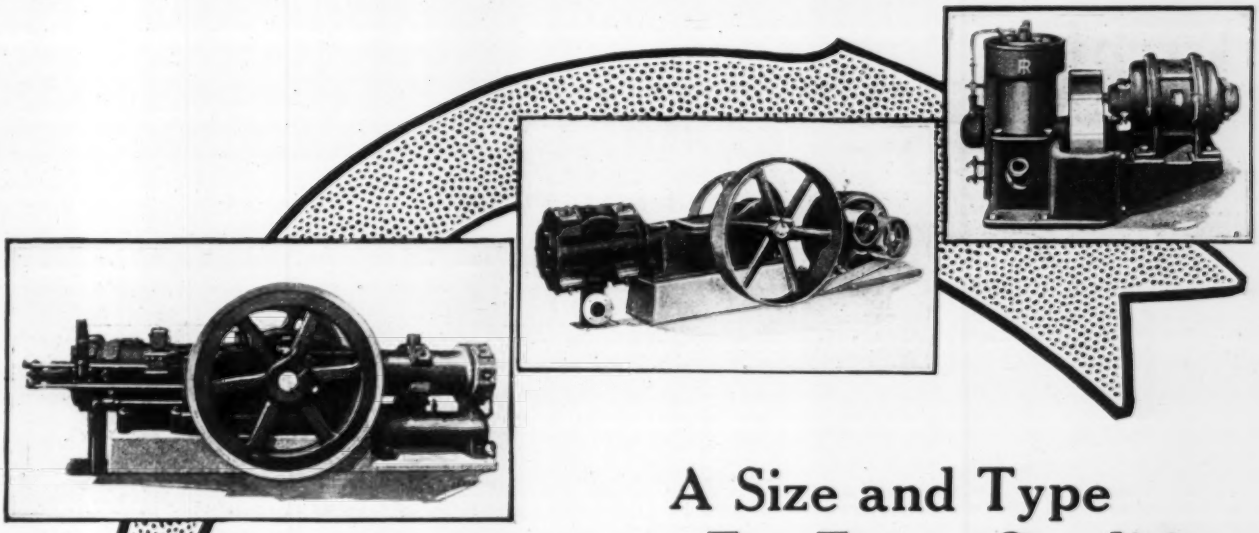
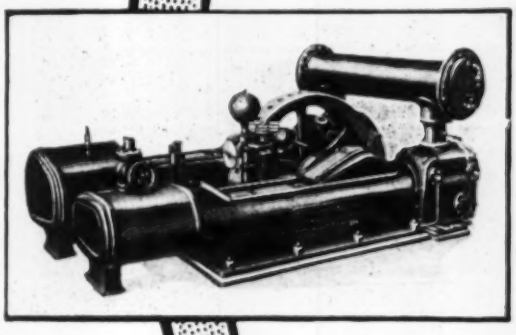
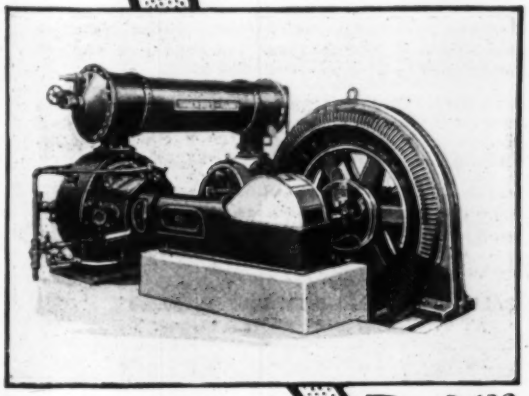
LOS ANGELES CALIFORNIA, U. S. A.

IR AIR COMPRESSORS







R-430

A Size and Type For Every Condition

NO matter what capacity, pressure or type of drive, one of the thousand and more types and sizes of Ingersoll-Rand Air Compressors will just fit your requirements.

There are standard compressors for pressures up to 3500 pounds per square inch, and for capacities ranging from 3 to 50,000 cubic feet of free air per minute.

The question of drive has been given the most careful consideration. Whether direct-connected electric motor drive, oil or gas engine, belt or steam drive is preferred you can purchase the *complete* compressor unit from the Ingersoll-Rand Company, with the assurance that every detail of compressor and prime-mover has been given correct attention.

In addition to air compressors the Ingersoll-Rand Company manufacture a complete line of gas and ammonia compressors. Our engineers are located in all parts of the world. These men are experts on the subject of air and gas compression and will be glad to discuss your problem with you. Also, these compressors are described in illustrated booklets, copies of which will be sent you on request.

INGERSOLL-RAND COMPANY
11 Broadway, New York

Offices in all principal domestic and foreign cities

See Our Data in 1922 A.S.M.E Condensed Catalogues of Mechanical Equipment

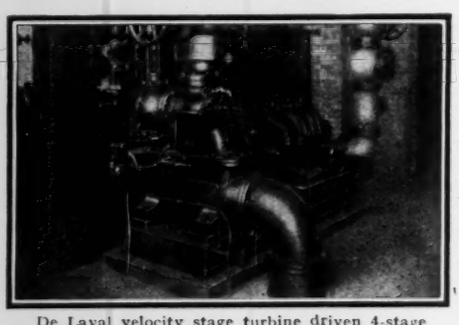
671-C

Ingersoll-Rand

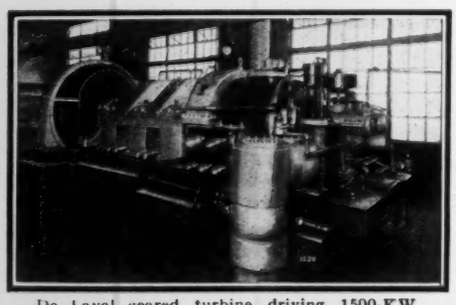
De Laval

Turbine Driven DC and AC Generators
Centrifugal Boiler Feed Pumps
Circulating and Condensate Pumps
Fire Pumps & Service Pumps
Centrifugal Blowers

De Laval motor driven service and fire pumps.



De Laval velocity stage turbine driven 4-stage 5-in. boiler feed pump; capacity 700 gals. per min. against 693 ft. head.



De Laval geared turbine driving 1500-KW., D. C., house generator.

De Laval velocity stage turbine driving forced draft blower.

THE trend towards higher steam pressures, superheats and vacuums has presented entirely new problems to designers. Excellence of design, with workmanship and materials of the highest grade, is equally as important in auxiliary equipment as in main units, since the main units cannot remain in operation without the auxiliaries and failures of auxiliaries may result disastrously to the main units. De Laval auxiliary equipment has been designed to meet these requirements.

Low bucket speeds and liberal design insure safety. Separate speed governor and overspeed emergency trip control the steam supply by independent valves. Steam chests are made of steel and so located that heat is not conducted to the bearings. The oiling system is automatic. Governor levers and parts requiring adjustment are so located as to be easily accessible.

A standard speed generator driven by a De Laval geared turbine is a more efficient, more reliable and more durable unit than a high-speed generator driven by a steam turbine or a generator driven by a reciprocating engine.

Geared turbines should be used for driving circulating pumps, since low-speed pumps are more efficient, more reliable and longer-lived than are high-speed pumps.

De Laval turbine driven centrifugal boiler feed pumps, condensate pumps, fire pumps, and general service pumps directly connected to turbines, make exceedingly simple, reliable and compact units.

Centrifugal forced draft blowers and induced draft fans driven by De Laval geared turbines are free from the vibration and other troubles incidental to high-speed fans. The bearings are amply lubricated and cooled by a forced circulation of oil.

De Laval geared steam turbines are directly connected to medium or slow speed machinery, such as stokers, ash conveyors, coal crushers, etc., and combine high efficiency with extreme ruggedness and reliability.

The De Laval double helical speed reducing gear has been perfected in respect to both design and method of manufacture by extensive application to high-speed turbine service during the past 25 years. Its smooth and efficient operation is attested by its exceeding quietness.

CALL AT OUR EXHIBIT, BOOTH NO. 69
AT THE NATIONAL POWER SHOW.

See Our Data in 1922 A.S.M.E Condensed Catalogues of Mechanical Equipment

De Laval
Steam Turbine Company
Trenton, New Jersey

Local Offices: Boston, New York, Philadelphia, Pittsburgh, Cleveland, Indianapolis, Chicago, Duluth, Kansas City, Denver, Salt Lake City, Charlotte, Atlanta, Birmingham, New Orleans, Dallas, Seattle, San Francisco, Los Angeles, Montreal, Toronto, Vancouver.

246

"Let's stay over for the POWER SHOW"

THIS is what members of the A.S.M.E. and A.S.R.E. will be saying to each other toward the close of the annual December meeting of the Society, for the Power Show is to begin immediately after. This most complete exhibition of power plant equipment ever shown under one roof is to be held at the

Grand Central Palace

New York City
December 7-13, 1922
(except Sunday)

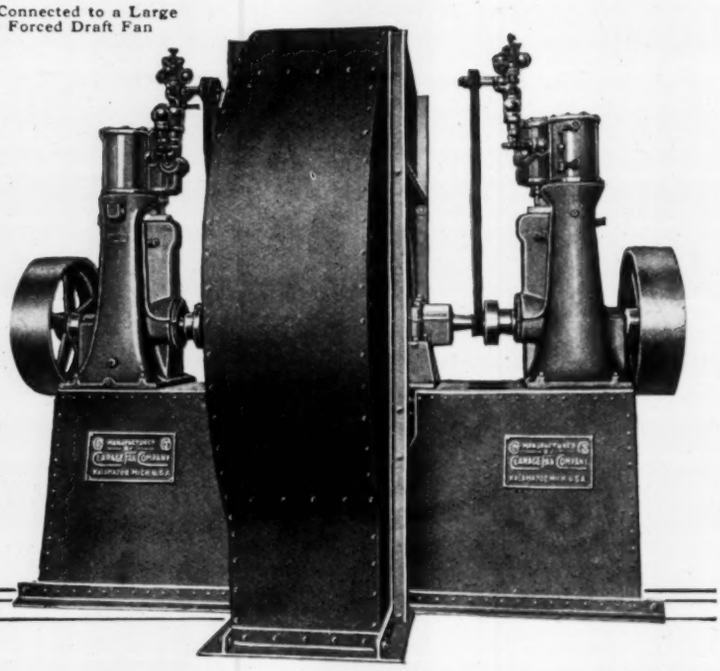
Thousands of prominent engineers from all over the country will be in attendance.

Representatives of the most progressive manufacturers of power plant appliances will be at the exhibits. No engineer can afford to miss this opportunity to personally inform himself on the latest developments in the power plant field.

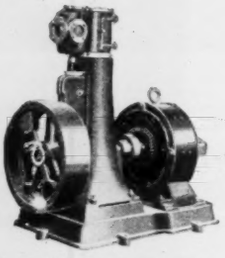
Before you leave town, **See the Power Show!**

National Exposition of Power and Mechanical Engineering
Grand Central Palace, New York City
Room 1102

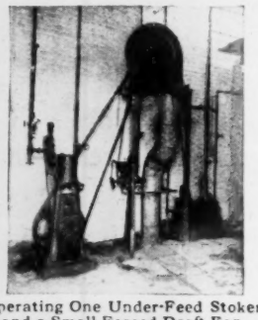
Direct Connected to a Large Clarage Forced Draft Fan



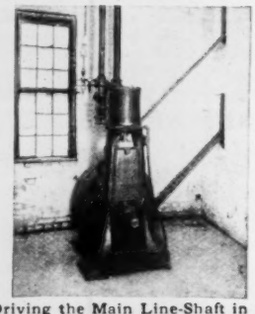
A FEW USES
FOR CLARAGE STEAM ENGINES



Clarage Engine Generator Set



Operating One Under-Feed Stoker and a Small Forced Draft Fan



Driving the Main Line-Shaft in a small factory

Driving An Air Compressor

Power at Low Cost

TESTS conducted under average operating conditions, both on the test block and in actual service, have clearly demonstrated the economy of Clarage engines. The steam consumption is unusually low, while the oil required is but a fraction of that used in the ordinary engine.

The fully enclosed features, together with the automatic pump oiling system, assure long continued service—year after year. Installation records establish the fact that Clarage Type "V" Engines demand no special attention and very rarely need any repairs, even though they have been in operation a long time.

These engines are used successfully for driving stokers, mechanical draft fans, electric generators, centrifugal pumps, air compressors and main line shafts in small factories.

If you have a job for a small steam engine—where economical, continuous operation is essential—let us give you complete information on the Clarage Type "V" unit. Send for catalog No. 6.

CLARAGE FAN COMPANY

BRANCH OFFICES IN PRINCIPAL CITIES

Main Office and Factory, KALAMAZOO, MICH.

CLARAGE — KALAMAZOO TYPE V SELF OILING ENGINES

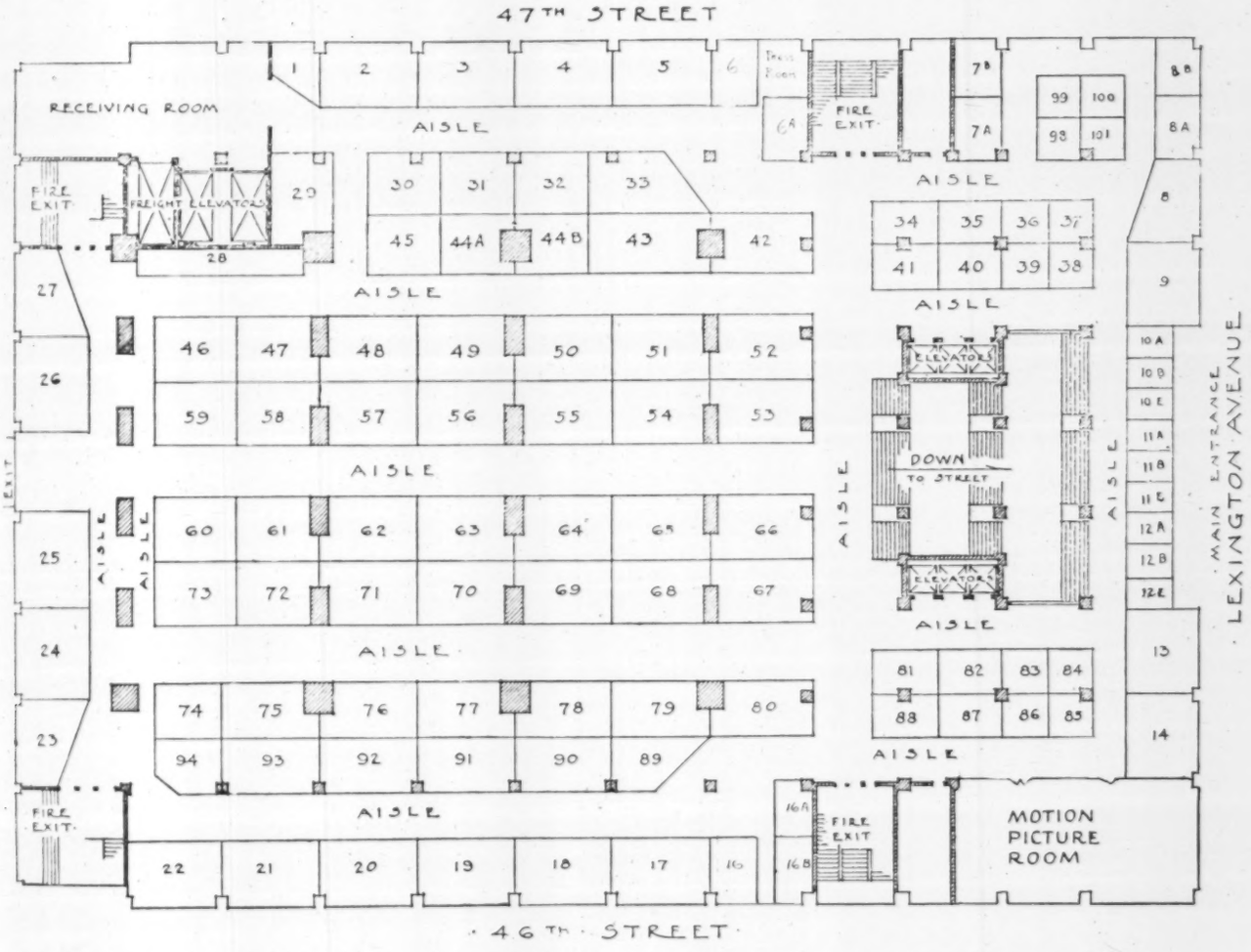
Diagram of Floor Spaces

at the

National Exposition of Power and Mechanical Engineering

To be held at

Grand Central Palace, N. Y. City, December 7–13, 1922, Excepting Sunday



THE Following Color Pages contain information regarding the exhibits or products of firms listed below who will be represented at the exposition. Each firm's booth may be located readily by referring to the numbered diagram of floor spaces shown above

List of Advertisers in this Color Section

Name of Advertiser	Booth No.	Page No.
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Davidson, M. T. Co.	98	26
Deane, Payne Ltd.	4, 44B, 46	25
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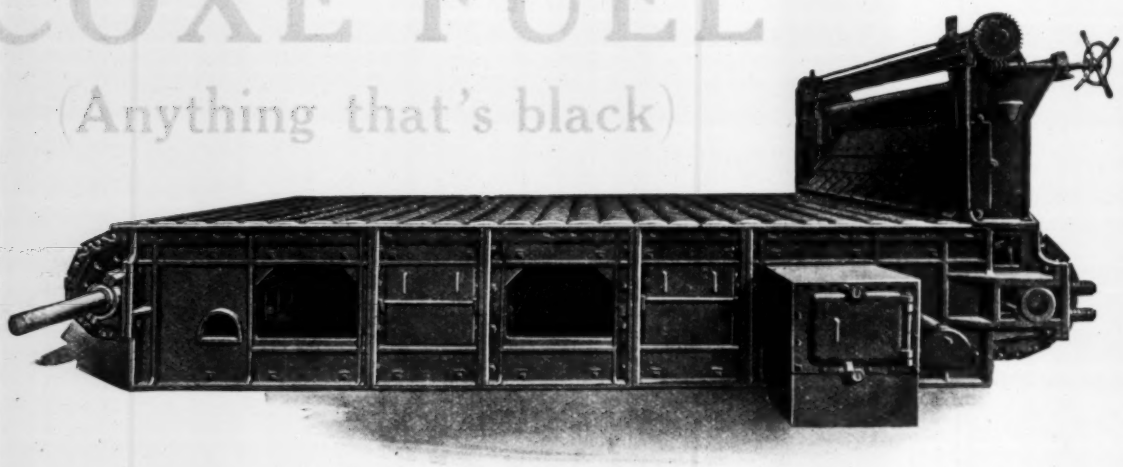
H.S.B.W.-Cochrane Corp'n	67	27
Jenkins Bros.	90	20
King Refractories Co.	36	33
Leather Belting Exchange	75	31
Lunkenheimer Co.	46	24
Martin-Morse Corp'n	8B	31
Otis Elevator Co.	43	32
Quigley Furnace Specialties Co. (Inc.)	89	19
Reading Steel Casting Co. (Inc.)	44B	34, 35
Smith & Serrell	85	30
Tide Water Oil Sales Corp'n	31	29

COXE FUEL

(Anything that's black)



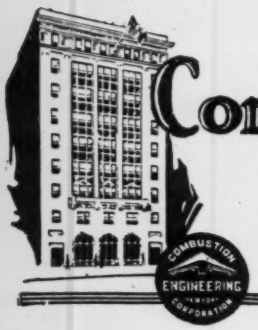
Is there any particularly cheap grade of coal, available at your plant, which at present you cannot burn efficiently?

Coxe Stokers

have established remarkable records in utilizing **efficiently,** fuels which have heretofore been considered unburnable.

Perhaps we can help you cut your coal bill. It will at least be interesting to you to find out. Write us.

See our exhibit at Booths 23-24-25
Exposition of Power
and Mechanical Engineering
Grand Central Palace—New York—Dec. 7 to 13



INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

Combustion Engineering Corporation

Combustion Engineering Bldg.—43 Broad Street New York City

Offices in Principal Cities Throughout the World

Frederick Multiple Retort Stokers
Type E Stokers
Type D Stokers
Type K Stokers
Type H Stokers
Self Contained Stokers

Lopulco Pulverized Fuel Systems
Coxe Stokers
Grieve Grates
Air Heaters
CEC Tube Scraping Device
Combusco Water Seal Conveyors

New Linings for Old

Salvage Your
OLD FIRE BRICK

Use them for Rebuilding and to

REPAIR FURNACE WALLS

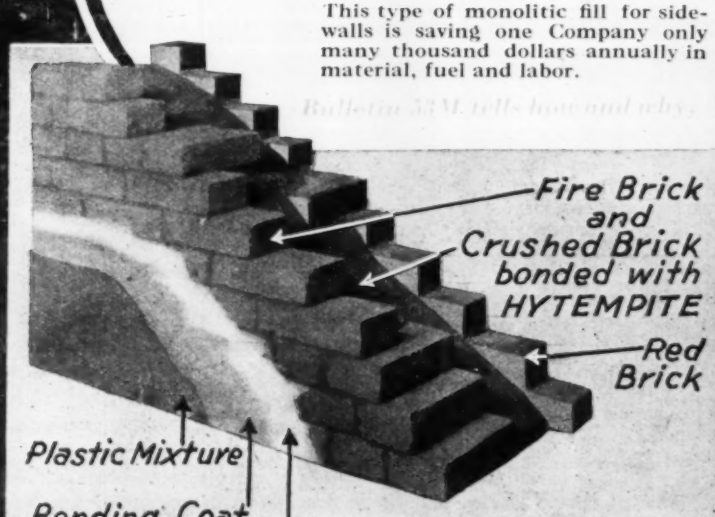
By Crushing them and Bonding them with

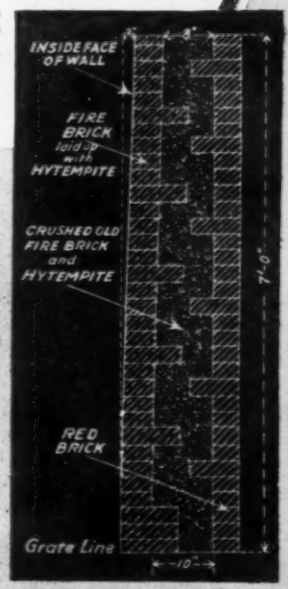
HYTEMPITE

Reg. U. S. Pat. Off.

This type of monolitic fill for side-walls is saving one Company only many thousand dollars annually in material, fuel and labor.

Bulletin 33M tells how and why.





QUIGLEY Furnace Specialties Co. Inc.
26 Cortlandt Street New York

Branch Offices
Chicago — Philadelphia
Distributors in all industrial centers.

Jenkins

REG. U.S. PAT. OFF.
TRADE
JENKINS
MARK
Jenkins Bros

That he who specifies may know

We stamp the Jenkins Diamond and signature on every valve we make—

as an evidence of our pride in workmanship

as a protection against substitution

as an assurance to the user that he is getting Jenkins "Diamond" Valves and genuine Jenkins service.

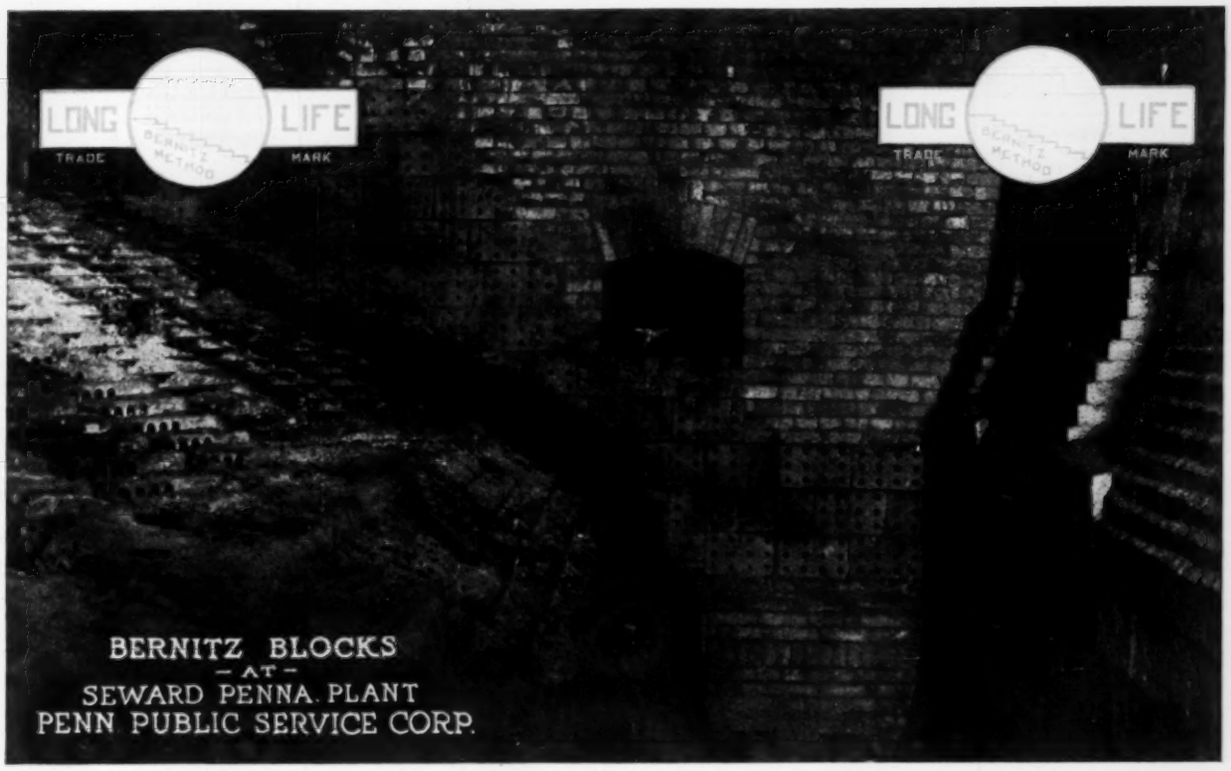
We cordially invite you to visit our exhibit (Space No. 90) at the NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING EQUIPMENT. In addition to the Jenkins Valves you know so well, we want you to inspect several new valves recently perfected.

JENKINS BROS.

New York Boston Philadelphia Chicago
Montreal London

FACTORIES: Bridgeport, Conn.; Elizabeth, N. J.; Montreal, Canada.

Valves



BERNITZ CLINKER-PROOF BLOCKS

Shape "E" shown here is 13½"x7⅝"x7" deep, replaces nine std. fire brick

See our catalogue for other shapes and complete information

FIRE FACE REAR FACE

BERNITZ BLOCKS—which are made of high grade refractory clay, and protected by the BERNITZ SYSTEM—prevent clinker adhesion on furnace linings, thereby assuring *"long-life"* to the settings, maximum furnace efficiencies, increased capacities, and elimination of the arduous task of removing troublesome clinkers.

BERNITZ BLOCKS are readily installed in existing as well as new furnaces and are in use extensively at leading central stations and industrial power plants.

At the ***New York Power Show*** (***Dec. 7-13, 1922***) will be exhibited an actual layout of these blocks as adapted to a furnace equipped with a multi-retort stoker. You may obtain at our booth descriptive catalogues and complete information, or the same will be gladly sent to you upon request.

See Our Data in 1922 A.S.M.E Condensed Catalogues of Mechanical Equipment

350 Madison Ave., New York City — **177 State St., Boston, Mass.**

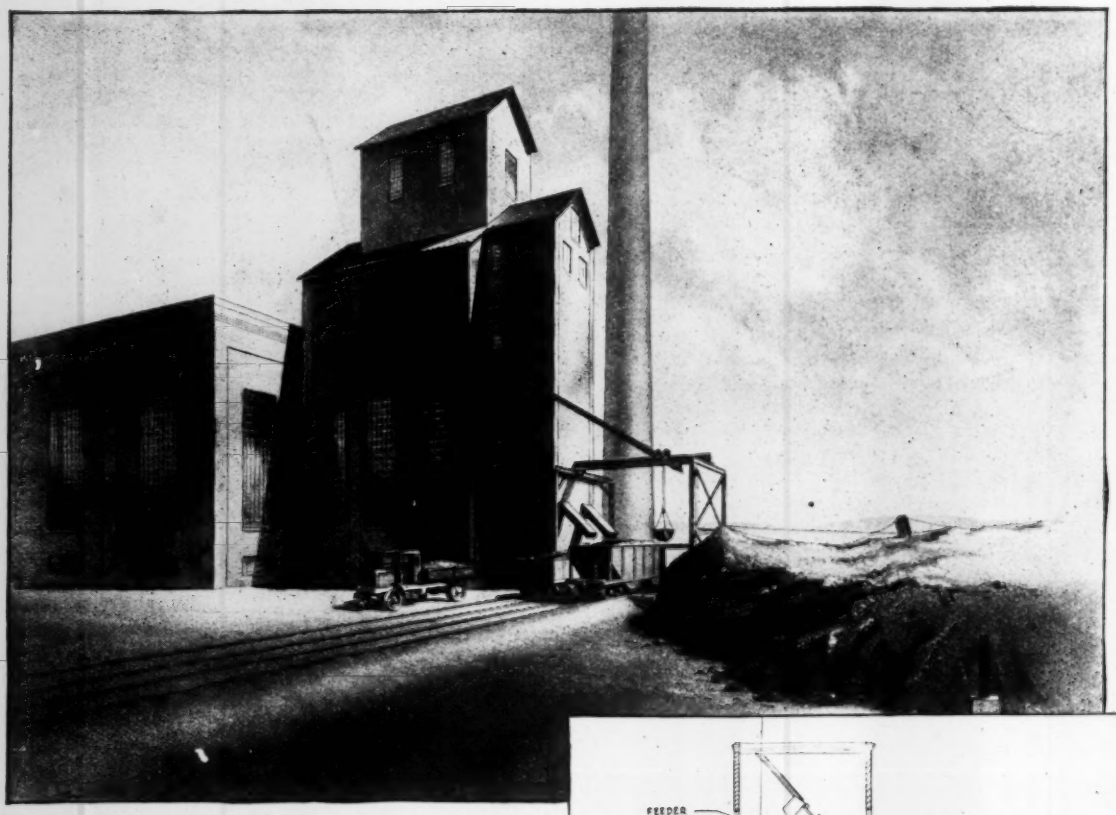
BERNITZ FURNACE APPLIANCE CO.

PITTSBURGH PHILADELPHIA CLEVELAND CHICAGO ATLANTA DETROIT ST. LOUIS.

NATIONAL EXPOSITION OF POWER & MECHANICAL ENGINEERING

-SPACE 78-

Beaumont Equipment Will Concentrate



Booth No. 50 at the National Exposition of Power and Mechanical Engineering will show miniature working models of the Beaumont Skip Hoist, the Beaumont Weigh Larry, and the Beaumont Cable Drag Scraper. Be sure to see them.

Super-Central System for coal and ash handling, designed by Beaumont for the Neosho Steam Station of the Kansas Gas & Electric Co., at Strauss Kans.—one of the properties of the Electric Bond & Share Co. Building is of inexpensive construction, yet architecturally pleasing.

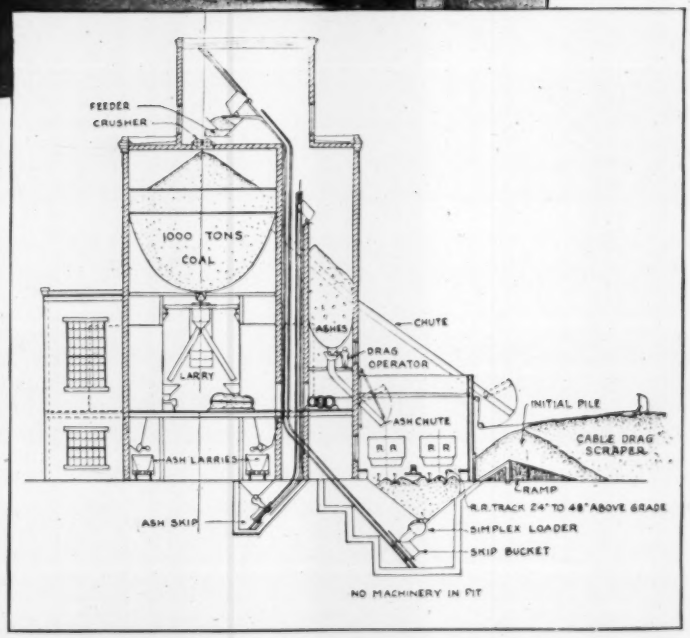


Diagram view of the Super-Central System. Building contains Beaumont Skip Hoists and bunkers for coal and ashes, driving machinery for Beaumont Cable Drag Scraper storing coal, and terminus of tracks of Beaumont Weigh Larry feeding coal to boilers.

SKIP HOISTS
COAL WEIGH LARRIES
CABLE DRAG SCRAPERS
STEEL ASH BUNKERS
COKE SCREENING PLANTS
CONCRETE COKE BUNKERS

Beaumont

SUSPENDED Steel Coal BUNKERS
ASH HOPPERS and GATES
CRUSHERS and FEEDERS
SINTERING PLANTS
TRACK HOPPERS
CONVEYORS
ELEVATORS

R·H·BEAU

CHICAGO . . . . 1406 S. Michigan Ave.
BOSTON . . . . . 261 Franklin Street
MINNEAPOLIS . . . . . 501 So. 6th St.
GREENVILLE, S. C. Masonic Temple Bldg.

332 Arch Street

Your Coal and Ash Handling at One Point

CONCENTRATION of all coal and ash-handling equipment in one building of inexpensive construction is made possible by the super-central system devised by Beaumont.

Two Beaumont Skip Hoists, one for coal and one for ashes; a Beaumont Cable Drag Scraper for storing and reclaiming coal; a Beaumont Weigh Larry for feeding coal to stokers; and separate bunkers for coal and ashes comprise this complete system.

Winding machines operating skip hoists and drag scrapers are housed in same building with bunkers, which also contains terminus of larry tracks.

Because the necessary machinery is reduced to a minimum, and is of simple, rugged design, maintenance expense is very low. No chain elevators or distributing conveyors are used, and power consumption is small.

Absence of bunkers from boiler room permits maximum light and ventilation in firing aisle.

Capacities of the super-central system can be regulated to meet the requirements of any plant, large or small. Future plant extensions can be cared for without additional equipment. If desired, the system can readily be adapted to the handling of pulverized coal.

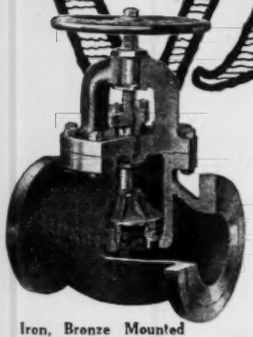
Complete details of the system and its component parts—the Beaumont Skip Hoist, the Beaumont Cable Drag Scraper, and the Beaumont Coal Weigh Larry—are given in Catalog No. 50. A free copy is here for you; write for it today.

MONT CO.

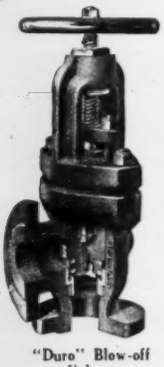
Philadelphia

NEW YORK . . . 50 Church Street
PITTSBURGH . . 1510 Oliver Bldg.
DENVER: 538 U. S. National Bank Bld.
CLEVELAND . . . 504 Bulkley Bldg.

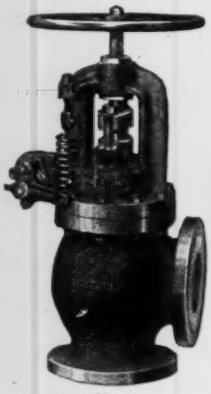
LUNKENHEIMER VALVES AND ENGINEERING APPLIANCES



Iron, Bronze Mounted and Cast Steel Monel Mounted Globe Valves.

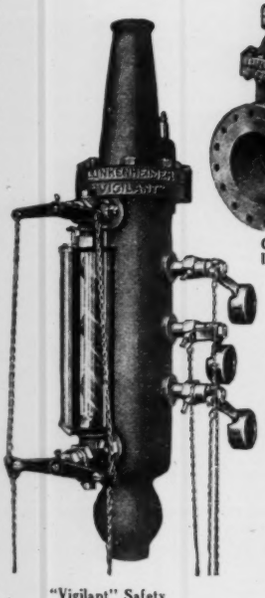


"Duro" Blow-off Valves.



Safety Non-return Boiler Stop Valves.

Cast Steel and Iron Gate Valves.



"Vigilant" Safety Water Column.

Pop Safety Valves.

Bronze Globe Valves.

"Lower cost per year of service,"—symbolized by economy both in operation and maintenance invariably results where Lunkenheimer Products are installed. Their record in service attests the supremacy of "quality,"—the factor which leads while progress lives, for QUALITY is ECONOMY.

The line being complete and providing a type and size for every requirement permits of standardization throughout the plant an accepted factor in promoting efficiency.

Lunkenheimer users are SATISFIED USERS. Specify "LUNKENHEIMER" and insist on getting the genuine.

Our catalog 58-D lists the complete line and also contains technical information of value to executives, engineers, designers, purchasing agents, etc. Let us send you a copy.

See our exhibit at the NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING Grand Central Palace, New York December 7th-13th

THE LUNKENHEIMER CO.
"QUALITY"
LARGEST MANUFACTURERS OF HIGH GRADE ENGINEERING SPECIALTIES IN THE WORLD
NEW YORK CHICAGO CINCINNATI, U.S.A. BOSTON LONDON
EXPORT DEPT. 129-135 LAFAYETTE ST., NEW YORK

Bronze Gate Valves.

32-33-4

America's Best since 1862

Dean Controls may be seen at the Exhibits of Lunkenheimer Company, Booth No 46—Pittsburgh Valve, Foundry & Construction Co., Booth No. 4—and Reading Steel Casting Co . Booth No. 44B

"DAVIDSON" PUMPS

Do the Work Economically!

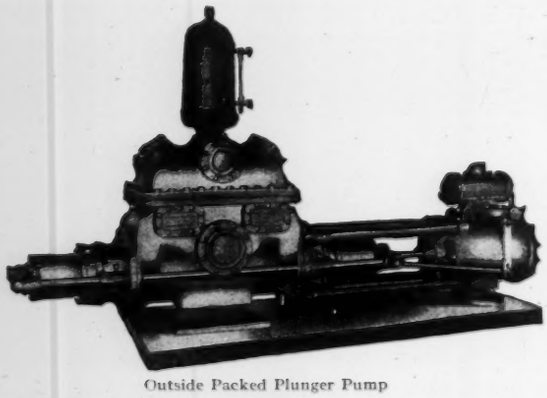
For almost half a century "DAVIDSON" Pumps have been built to a uniformly high standard of excellence.

This has been our unalterable policy.

"DAVIDSON" Pumps can be depended upon always, for thoroughly satisfactory service, low operating and maintenance costs,—and to last.

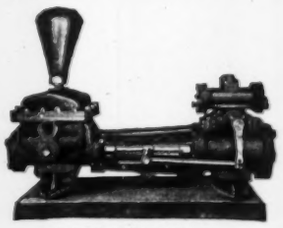
Design, materials, workmanship—all of the best, combine to produce a pump which, especially adapted for the duty required, will give the user the service he has a right to expect.

What are your present pump requirements?

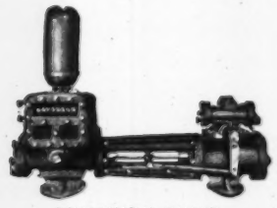


Outside Packed Plunger Pump

SPACE 98
Main Floor
POWER SHOW
Grand Central Palace
Dec. 7 to 13, 1922



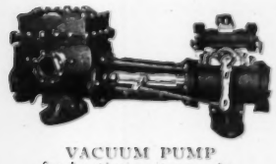
PRESSURE PUMP
Discharge Chamber Pattern



PRESSURE PUMP
Open Front Cylinder

PRESSURE PUMP
Hand Hole Cylinder

AUTOMATIC RETURN
PUMP AND RECEIVER



VACUUM PUMP
for heating systems etc

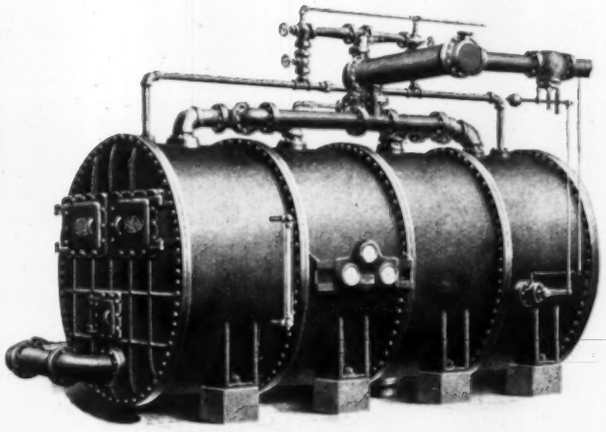
M. T. DAVIDSON COMPANY

Works: **43-53 Keap Street, Brooklyn, N. Y.** ***Main Sales Office:*** **154 Nassau Street, New York**

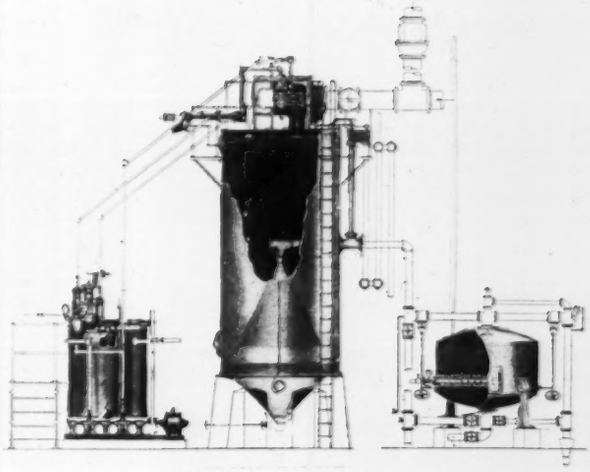
BRANCH OFFICES:

BOSTON: 135 Oliver St. PHILADELPHIA: 617 Cherry St. WASHINGTON, D. C.: 817 Albee Bldg.

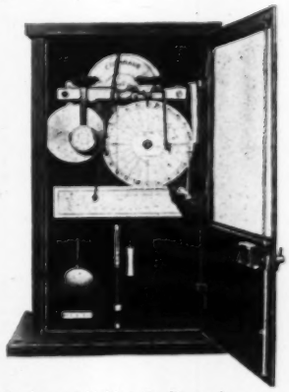
1224 Granite Bldg., Rochester, N. Y.; 609 Wade Bldg., Cleveland, Ohio; 324 Stimson Bldg., Los Angeles, California; 354 Colman Bldg., Seattle, Washington; Brock Sharp Machinery Co., Jacksonville, Florida; Wm. C. Churchill, 320 Jackson St., Oshkosh, Wisconsin; 604 Empire Bldg., Detroit, Michigan; 11 Church St., Albany, N. Y.



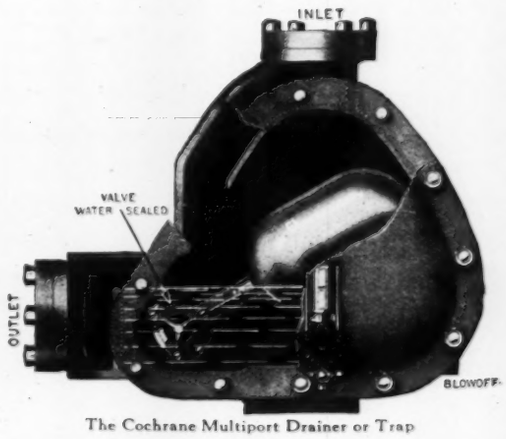
Cochrane Vacuum Deaerating Heater for supplying oxygen-free water at reduced temperatures.



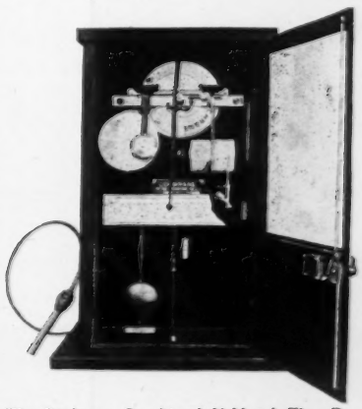
Cochrane Hot Process Softener.



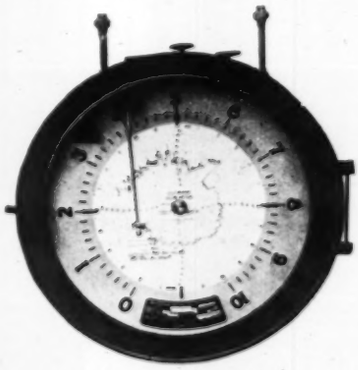
Cochrane V-Notch Recorder combined with Feed Water Thermometer and with circular chart.



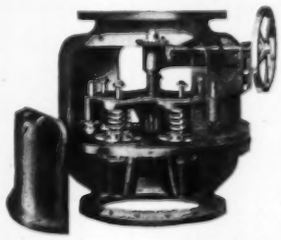
The Cochrane Multiport Drainer or Trap



The Cochrane Combined V-Notch Flow Recorder and Recording Thermometer.



Cochrane Flow Meter for Steam or Water in pipes.



Cochrane Multiport Back Pressure Valve.

TO ECONOMIZE—COCHRANIZE

THE novel and improved appliances shown herewith will be exhibited at the **National Exposition of Power and Mechanical Engineering,** at Grand Central Palace, Lexington Avenue and 46th Street, New York City, December 7th to 13th, 1922. The Cochrane **Booth No. 67** is at the left as you come up the stairway from the street.

If you operate a steam plant, if you use live or exhaust steam or hot water, if you wish to meter steam, air or water or to heat, soften or deaerate water to prevent scale or corrosion in boilers, economizers or piping, you will be able to obtain highly interesting and valuable information at the Cochrane Booth.

Meet our engineers and receive copies of our latest literature. If you are unable to come to the Exposition, state which one of the several appliances interests you and we will gladly mail our publications.

H.S.B.W.-COCHRANE CORPORATION

Formerly Harrison Safety Boiler Works

3199 North 17th Street **Philadelphia, Pa.**

Also at Atlanta, Baltimore, Birmingham, Boston, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Greenville, South Carolina; Hazleton, Pa.; Houston, Indianapolis, Kansas City, Little Rock, Los Angeles, Minneapolis, New Orleans, New York, Pittsburgh, Richmond, Rochester, St. Louis, Salt Lake City, San Francisco, Seattle, Syracuse, Tucson, Toronto, Montreal, Halifax.

179

See This Exhibit

at the

POWER SHOW

Grand Central Palace—New York

December 7th to 13th, 1922

We invite your inspection of the following:

Miniature Boiler in Service demonstrating operation of Bailey Boiler Meter and Bailey Multi-Pointer Gage.

V-Notch Weir Meter in operation with water flowing through glass pipe demonstrating orifice principles.

Indicating and Recording Tachometers.

Gravity Recorders for Liquids (Compensated for Temperature Variations).

Meters for Granular Materials.

Totalizing Boiler Meter (for use on double outlet boilers).

Steam Meters.

Differential Gas Pressure Recorder.

Gas Meter with Pressure Compensator in operation.

Descriptive bulletins describing the various types of Bailey Meters will be sent upon request.

BAILEY METER COMPANY

2009 East 46th Street Cleveland, Ohio

You'll find us here

POWER SHOW

Grand Central Palace
New York, Dec. 7th to 13th

Over on space 31 Tide Water will have an exhibit of unusual interest. A feature of the display this year will be the continuous daylight projection of our motion picture, "The Story of Tide Water Oil."

From the oil well to the engine room storage tank is a long and eventful journey. Our motion picture spans this gap of time and distance—come with us on a fifteen minute trip through the entire petroleum industry.

Then watch our animated comedy by Tony Sarg. The plot starts in the engine room. Trouble is brewing and the engineer knows it. He knows the reason—improper lubrication. And right here is where . . . . but it is too good to give away. Come and see it. It will test your gravity!

And there will be a warm welcome for all our friends who wish to make their headquarters at our booth.

Remember—Booth 31.

TIDE WATER OIL
SALES CORPORATION
INDUSTRIAL OIL DEPT. 11 BROADWAY, N. Y.

See Our Exhibit—Space No. 85—Main Floor

National Exposition of Power and Mechanical Engineering—Grand Central Palace, New York, Dec. 7-13

FRANCKE FLEXIBLE COUPLINGS FOR DIRECT-CONNECTED MACHINES

PINTITE RIGID COUPLINGS FOR LINE SHAFTING

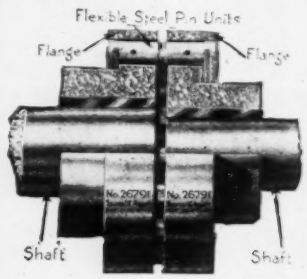
All Metal, Any Size, Any Power, Any Service
"To make good machines last longer"

New Fractional H.P. Type

Small, inexpensive sizes only for small motor driven generators, fans, pumps, sewing machines, and for magneto and pump drives, etc.

Light Duty Type (1921) and Heavy Pattern Type (Since 1912)

In capacities from ⅔ H.P. per 100 R.P.M. and shafts ½" dia. up to 3200 H.P. per 100 R.P.M. and shafts up to 13½" diameter.



For all usual direct connected drives where a flexible coupling should be used to provide for the errors in shaft alignment. Each "FRANCKE" also provides an easy means to line up the connected shafts, it cushions load shocks and vibrations, and it acts as a safety device in case excessive misalignment results from an operating accident.

Double, Floating-Ring Type (1914)

Recommended for continuous process drives and where excessive misalignment is expected.

Has been built and used successfully on drives in capacities up to 8000 H.P. per 100 R.P.M. and for shafts up to 18⅞" diameter.

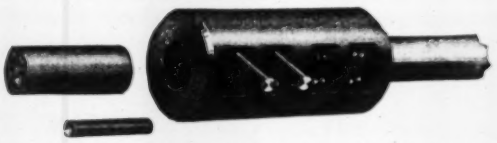
Marine Type (1912)

Constructed with a center bolt to transmit the thrust and reverse pull from the propeller shaft. Small sizes.

New High Speed Type

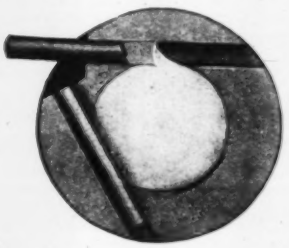
Now being developed and offered for high speed motor and turbine driven herringbone gear units, etc.

A properly sized all-metal "FRANCKE" lasts longer and provides proper flexibility. Is your name on our mailing list?



"Pinned Tight"—These two words tell the grip of a PINTITE on the shafts which it connects—a grip that no service chain can break.

Install with the shaft ends together within the bore of the sleeve and simply drive the cup-ended pins home with a hammer.



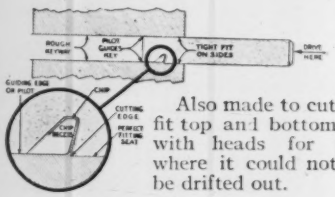
Each cup ended, hardened steel pin cuts its own seat in the shaft—a keyway deep enough to hold inflexibly but not deep enough to weaken the shaft.

To remove—Drive pins out backwards using a round end drift. Turn coupling on shafts then drive it off shafts and use again in a new or in the same location.

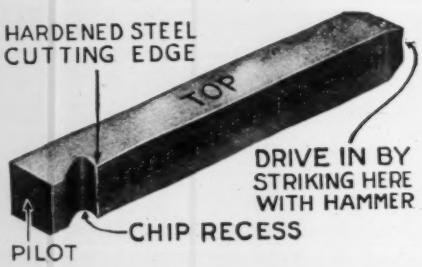
Since 1917

the self-fitting key which cuts the cost of all hand-fitting

Drive a "Keytite" into the ordinary keyseat and leave it there. The cutting edge sizes the rough keyways to make a finished fit. Does not require a skilled mechanic and always insures a correct fit.



Also made to cut and fit top and bottom, and with heads for places where it could not easily be drifted out.



KEYTITE SELF-FITTING KEYS

EVERY KEY SIZES AND FITS ITS OWN SEAT

SMITH & SERRELL

Coupling Specialists Since 1912

41 Central Ave., Newark, N. J.

BOOTH NO. 75

Leather Belting

Educationally
at the
Power and
Mechanical Engineering
Show

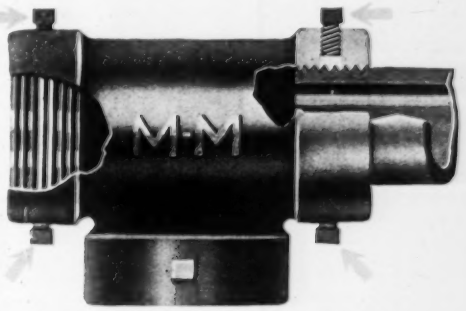
THE LEATHER BELTING EXCHANGE announces that at the Power and Mechanical Engineering Show, space 75, it will have an educational exhibit of leather belting, embodying and illustrating the research work which has been done by the Leather Belting Exchange Foundation, at the Mellon Institute of Industrial Research, and at Cornell University. There will be testing apparatus in operation, to illustrate the principles of the transmission of power by belting, and to demonstrate the especial value of the leather belt, and there will be in attendance engineers and others qualified to discuss the subject, with the purpose of giving the observer disinterested information regarding leather belting.

There will be available important literature on the subject.

All interested in belting will be heartily welcome

THE LEATHER BELTING EXCHANGE

The Only Pipe Fitting with an Interior—Leak-Proof—Lead Seal.



The Set Screws compress the Lead around the Pipe Thread.

"Tight Joint" FITTINGS

The only screwed Fitting that can be kept tight in service under all pressures and conditions.

Unexcelled for Ammonia, Air, Steam Vacuum lines; High pressure Gas,—Gasoline, Kerosene, Crude Oil, and Hydraulic Pressure-Installations.

Made in all patterns for pipe from ¼ in. to 12 in. in diameter, and for all pressures up to 6000 lbs. per sq. in.

Take the place of Standard and Extra Heavy Flanged Fittings at a Great Saving in Cost --Weight—Handling—Erecting—making up and maintenance.

Send the Coupon in today

See our exhibit at the Power Show
Test them yourself up to 6000 lbs. pressure

Booth No. 8-B

MARTIN-MORSE CORPORATION

Manufacturers

143 Liberty Street
New York City

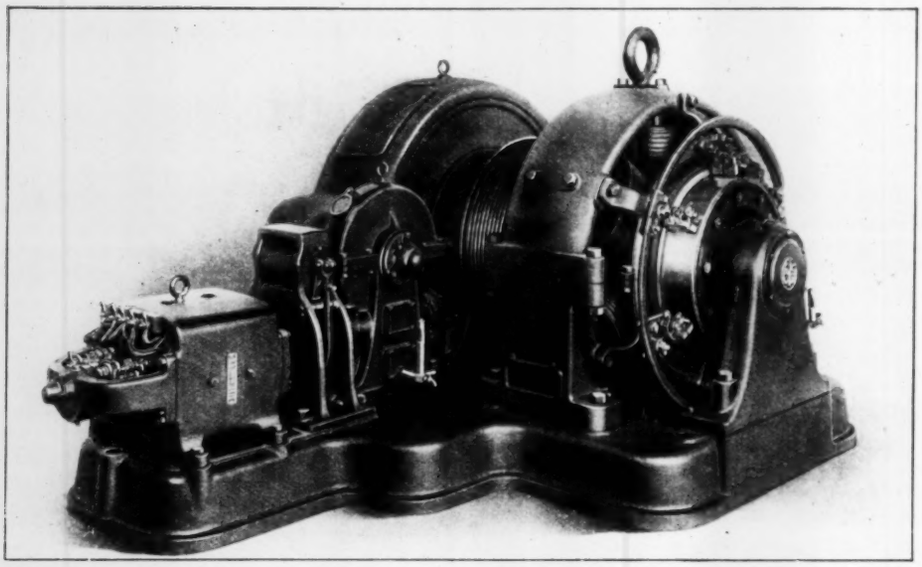
Factory:
Lyndhurst,
New Jersey

Martin-Morse Corporation, 143 Liberty Street, New York City
Gentlemen: Please send the following Tight Joint fittings for 60 day test and observation.
Size.....
Pressure.....
Style of fittings.....
Service.....
Name.....
Firm.....
Address.....

Booth No. 43

NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING

Grand Central Palace, New York
December 7th to 13th



YOU are cordially invited to visit our booth and see the latest type of Otis Gearless Traction Micro-Drive Multi-Voltage Elevator Machine in operation. This Machine automatically levels the car platform with the floor landing after the operator has brought the car to a stop within the leveling zone above or below the floor landing. The Multi-Voltage control takes current from the Balancer set in four steps of sixty volts each, and in proper sequence as the motor accelerates to full speed. This form of operation eliminates starting resistance as used with other types of elevators and provides the quickest and smoothest possible acceleration and retardation, and operates more economically than any other type.

The Exhibit consists of the complete electrical and mechanical equipment used with this type of elevator and includes the hoisting machine, motor, controller, balancer set (one set will operate a number of elevators) the car operating switch, micro-leveling switch, stopping switch, speed governor and car safety devices.

OTIS ELEVATOR COMPANY

Offices in All the Principal Cities of the World

See Our Exhibit

Booth 36

National Exposition of Power and Mechanical Engineering

See our moving Bulletin Machine displaying installations of materials we manufacture—also Model Boiler showing Mono Baffles installed.

FLAME BRAND

HIGH TEMPERATURE CEMENTS AND "MONO" BOILER BAFFLING

TRADE MARK

RED FLAME PLASTIC CEMENT
WHITE FLAME INSULATING CEMENT
BLUE FLAME FIRE BRICK CEMENT
PLASTIKDO REPAIRING CEMENT
RAMIT FOR RAMMED-UP LININGS

"MONO" Boiler Baffling

Reduces Fuel Waste

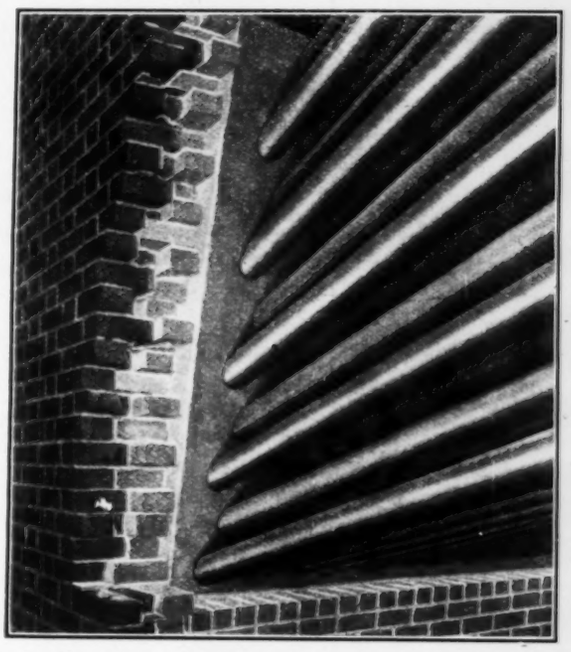
and Increases the Efficiency

because it is built in *one solid monolithic piece* and hugs the tubes and walls closely, regardless of the angle at which it is set. It will not spall or crack, and is not damaged by the withdrawal and replacing of tubes when ordinary care is taken.

"Mono" Boiler Baffling may be installed in any position, in any boiler; no heat is required to set the material; and it should last as long as the boiler itself.

Do *you* know at what temperature the gases are leaving *your* boilers? And what the temperature *should be* at different pressures and ratings? Undoubtedly the conditions could be improved by better baffling.

The services of our Engineering Department are at your disposal.



The illustration above shows a first pass 'Mono" baffle as seen through an opening in the side wall, looking toward the rear of the boiler. Note the absolutely monolithic construction—the close fit around tubes and against the walls—and the entire freedom from any possibility of leakage.

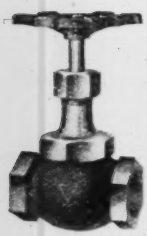
KING REFRACTORIES COMPANY, Inc.

New York Office: 707 Greenwich Street

Main Office and Works: 1709-1715 Niagara Street, Buffalo, N. Y.

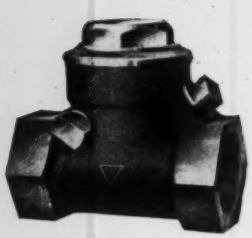
Boston, Pittsburgh, Detroit *Offices in all principal cities* **Philadelphia, Cleveland, Chicago**

PRATT & CADY VALVES



Bronze Globe and Angle Valves

Bronze Gate Valves



Bronze and Iron Swing Check Valves

Iron Body Gate Valves

These valves will be shown at Booth 44B, National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York, December 7th to 13th.

THE Pratt & Cady line of brass and iron valves and asbestos packed cocks offers a valve for your every need where the working conditions involve pressures up to 250 lbs. and temperatures up to 500° F; also hydraulic valves for pressures up to 800 lbs.

Since 1878 our policy has been to manufacture valves "as near perfect in design, material and workmanship as shall make them merchantable and of a character that will establish for this company a high reputation."

Following this policy we have built into all our valves renewable features that can actually be realized on under service conditions without removing the valve from the line.

Iron Asbestos Packed Cocks

READING STEEL

BRIDGEPORT

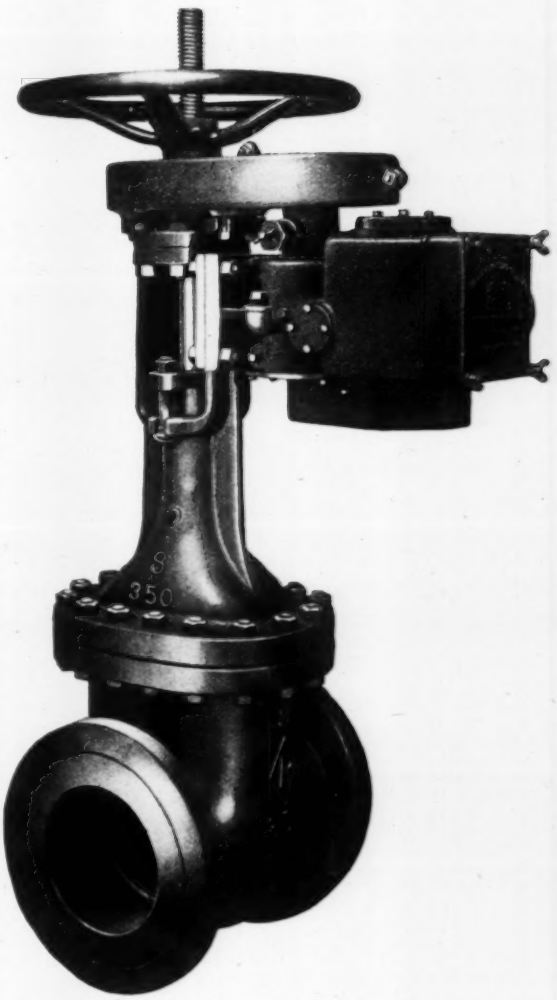
SAN FRANCISCO PHILADELPHIA ST. PAUL PITTSBURGH CHARLOTTE CLEVELAND

READING VALVES AND FITTINGS

THE Reading line meets your needs for those more severe service conditions for which good practice requires cast steel valves and fittings.

The Reading plant is devoted exclusively to cast steel, and during years of specialization has made continuous advances in shop practices that have resulted in products of superior quality.

This advantage of experience and facilities combined with the resources of valve experience at the Pratt & Cady plant place us in an unusually favorable position to manufacture steel valves.



A motor operated Reading cast steel gate valve with Dean Control. See the operation of this unit at our booth at the National Exposition of Power and Mechanical Engineering.

Cast Steel Flanged Tee

Cast Steel Flanged Elbow

Cast Steel Screwed Cross

Cast Steel Screwed Tee

CASTING CO., INC.

CONNECTICUT

BOSTON HARTFORD NEW YORK DETROIT CHICAGO HOUSTON

See Our Exhibit
Booth No. 41
National Exposition of Power and Mechanical Engineering
Grand Central Palace
New York, N. Y.
Dec. 7th to 13th

FURNACE ENGINEERING

that insures Maximum Efficiency

There will be a model on exhibition showing our various types of furnace equipment.

Are YOU getting *maximum* Furnace Efficiency?

Our Furnace Equipment is designed to give the greatest efficiency and to reduce to a minimum the shutting down for repairs.

All materials used in our Furnace Equipment are made from the most suitable grades for the various requirements and are carefully inspected and gauged before shipment. Thus our clients are assured of proper fitting equipment necessary for good service.

This service is backed up by an organization of experienced engineers with a record of successfully installing and operating various types of mechanical stokers and other furnace equipment.

Some of Our Installations

Monongahela Power & Railway Co.
United Electric Light & Power Co.
Consolidated Power Co.
West Penn Power Co.
New York Edison Co.
Public Service Electric Co.
American Gas & Electric Co.
Central Illinois Light, Heat & Power Co.
Richmond Light & Power Co.
Hudson Motor Co.
General Motors Co.
Firestone Tire & Rubber Co.

If you are not able to visit our exhibit—write to us or our nearest branch for information about our furnace equipment.

FURNACE ENGINEERING COMPANY, INC.
5 Beekman Street **New York, N. Y.**

Branch Service and Sales Offices

BOSTON PHILADELPHIA PITTSBURGH MONTREAL CLEVELAND CHICAGO DETROIT

First Large Plant Using Pulverized Coal Exclusively is Equipped with Edge Moor Boilers

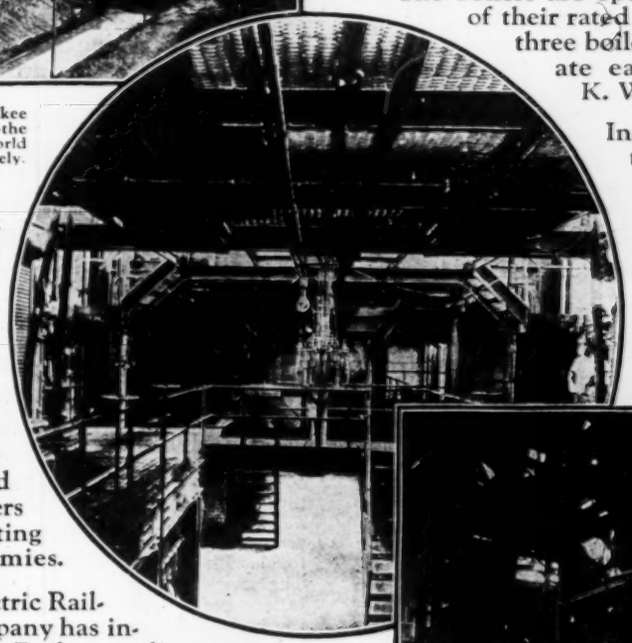
Lakeside Plant of the Milwaukee Electric Railway & Light Co.—the largest central station in the world using pulverized coal exclusively.

Installation at Lakeside Plant of Milwaukee Electric Railway and Light Co. shows highest efficiency among Central Stations

EIGHT 1306 H. P. Edge Moor Water Tube Boilers supply steam for the Lakeside plant—the largest power plant in the world using pulverized coal exclusively.

The boilers are operated normally at 250% of their rated capacity. At this output three boilers are sufficient to operate each of the two 20,000 K. W. turbines.

In a series of fifteen tests, the average efficiency of boilers, super-heaters and economizers was 87.3%. An efficiency of 85.6% has been obtained from the boilers alone.



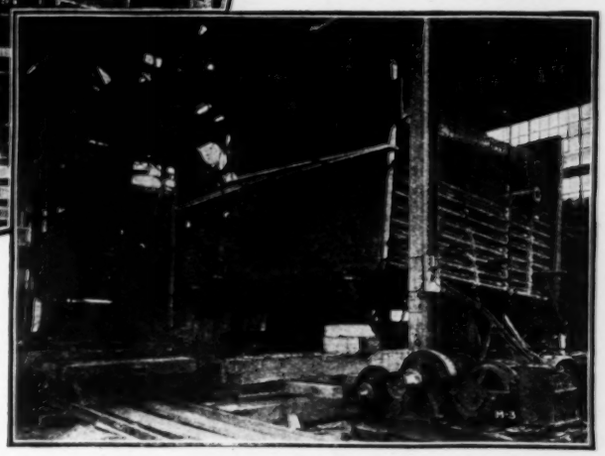
Boiler room at Lakeside Plant Eight 1306 H. P. Edge Moor Boilers in two rows of four each.

Flue gas analyses show average results of about 14.5% CO_2.

The success of this installation is typical of the performance of Edge Moor Water Tube Boilers. Operators of large and small plants find in Edge Moor Boilers a new means of effecting worth-while economies.

The Milwaukee Electric Railway and Light Company has installed 67 Edge Moor Boilers totaling 45,394 H. P. in its various plants, representing 23 separate orders.

The new Edge Moor catalogue contains information of value to every plant operator. Have you received your copy?



Two of the 5-drum, 4-pass Edge Moor Boilers during erection, Lakeside Plant.

EDGE MOOR IRON COMPANY

Established 1868

EDGE MOOR, DELAWARE

New York
Chicago
St. Paul

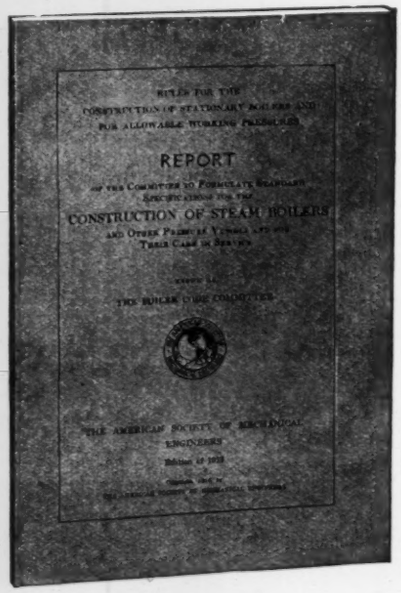
Boston
Pittsburgh
Charlotte

See Our Data in 1922 A.S.M.E. Condensed Catalogues.

EDGE MOOR Water Tube BOILERS

FOR INCREASED FUEL ECONOMY

A.S.M.E.
Boiler Code



1918 Edition

147 Pages, including appendix and index—35 Illustrations

Price $1.00 75c. to members

A REPORT containing standard specifications for the construction, equipment and use of steam boilers, and embodying the collective knowledge of the world's leading experts.

The A.S.M.E. Boiler Code is now operative as a legal construction code in the states of Arkansas, California, Delaware, Indiana, Maryland, Michigan, Minnesota, Missouri, New York, New Jersey, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, Utah and Wisconsin. It is also used as a standard by fifteen of the leading boiler insurance companies, leading boiler manufacturers and by many of our foremost consulting engineers. The U. S. Government now specifies that boilers for many important Departments are to be constructed in accordance with the A.S.M.E. Boiler Code.

Interpretations of the Boiler Code

The Boiler Code Committee meets monthly for the purpose of considering inquiries and rendering interpretations relative to the Boiler Code. When approved by the Council of the Society, these interpretations are published in MECHANICAL ENGINEERING and subsequently issued in data sheet form for convenience of reference.

The interpretations which have been issued by the Committee to date—nearly 400—cover matters of setting, erection and suspension, piping connections, as well as constructural details, and thus embrace a very valuable fund of information to everyone interested in steam boiler construction.

In view of the increasing recognition of the value of these interpretations to boiler manufacturers and users alike, and the fact that they are universally accepted in the seventeen states and ten cities in which the A.S.M.E. Boiler Code is operative, it is felt that many users of the Code will be desirous of keeping in close touch with the rulings made by the Committee and The Society is now prepared to furnish these interpretations regularly as issued following the meetings of the Boiler Code Committee. **The Subscription price is $1.50 per annum.**

Complete sets of Interpretations from Case No. 200 to date are also obtainable at $1.50 a set (To members $1.25).

OFFICIAL BOILER STAMPS

Stamps for impressing the official symbols on power boilers as shown in Fig. 23 (page 87 of the Boiler Code, Edition of 1918), are obtainable only from THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS (see Par. 332, Boiler Code). The stamps are obtainable in two forms, one, the regular hand stamp with ¾ in. symbol, at $3.00 each, and the other, a special hammer-type stamp, with ½ in. symbol at $3.00 each. The hammer-type stamp is particularly serviceable for stamping thin boiler plate.

It is the requirement of the Boiler Code Committee that the boiler manufacturer in purchasing the official boiler stamp shall furnish an Affidavit on a special blank form obtainable from the headquarters of the Society. It is expected that the order for each stamp purchased shall be accompanied by one of these Affidavits properly filled out and with the signature of the company officially acknowledged by a Notary Public. This requirement for the stamp is solely for the purpose of safeguarding the use of the stamp in certifying that power boilers are built to the requirements of the A.S.M.E. Boiler Code.

Manufacturer's Data Report Forms

Manufacturer's Data Report Forms are also offered for sale for the convenience of manufacturers who desire to enter power boilers in different states where the A.S.M.E. Boiler Code is operative. These blank forms are available at the following prices:

Single Copies 5c each

In lots of 6– 24....3c each
In lots of 25–100...2c each
In lots of 100 or more
1½c each

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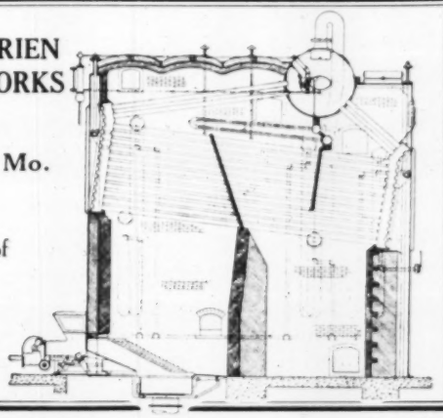
Four Types of

WATER TUBE BOILERS



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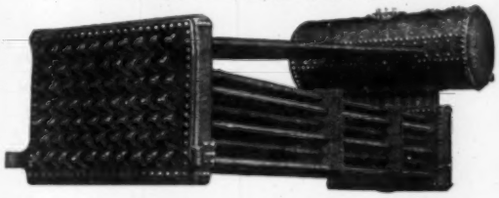
CHICAGO, ILL.
STEAM BOILER HEADQUARTERS



Water Tube
Cross Drum
Return Tubular

BOILERS

Plant at
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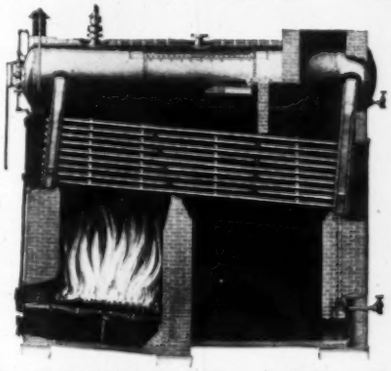
KEELER

BOILERS,

WATER TUBE AND RETURN TUBULAR



ARE RELIABLE AND SAFE

No Keeler boiler has ever exploded.
ECONOMICAL; cost of upkeep phenominally low.
EFFICIENT; numerous tests tell

Catalog of either type on request.

E. KEELER CO., Williamsport, Penna.

BRANCHES: NEW YORK PHILA. BOSTON BUFFALO PITTSBURGH CHICAGO

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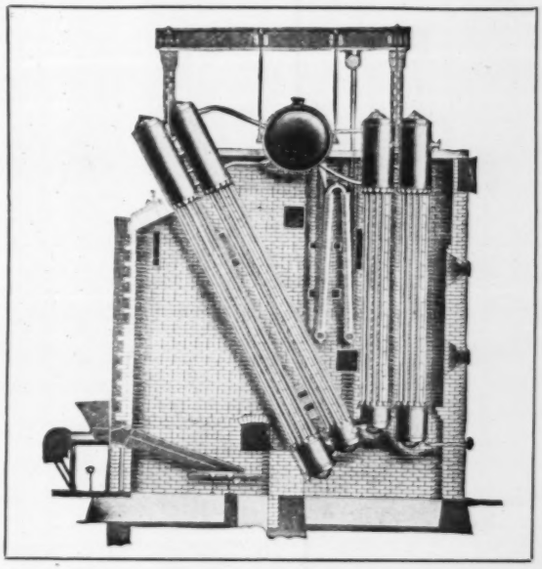
A Big Factor In Plant Economy



BIGELOW-HORNSBY WATER-TUBE BOILERS

will save money in steam production. Better furnace design with ample combustion space for the gases, the extra large percentage of direct heating surface exposed to the fire with assured unrestricted circulation and a 100 per cent tube area steam release establish ideal operating conditions.

Their actual economy records speak for themselves. Investigate. Send the coupon.

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12-22

Date.....

The Bigelow Company
20 Lloyd Street
New Haven, Conn.

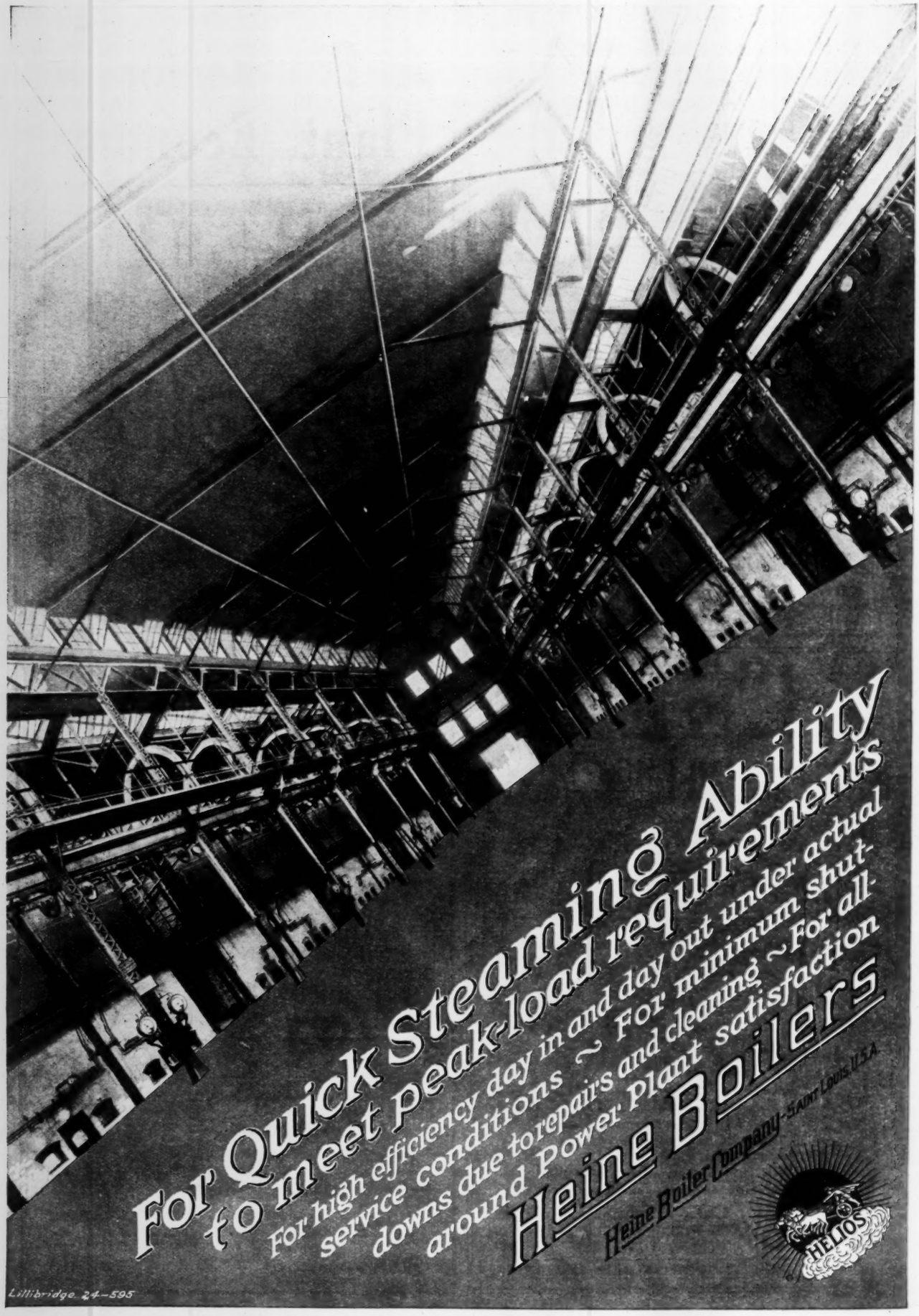
Gentlemen:

Please send me a copy of your Catalog on Bigelow-Hornsby Water Tube Boilers.

Name.....

Address.....

Post Office.....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to meet peak-load requirements
For high efficiency day in and day out under actual
service conditions ~ For minimum shut-
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Heine Boilers
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HELIOS
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TITUSVILLE

TITUSVILLE HORIZONTAL TUBULAR BOILERS FOR STEAM HEATING

Constructed in exact accordance with the A.S.M.E. Boiler Code.

Designed for a maximum working pressure of fifteen pounds to the square inch.

Subjected to a hydro static test pressure of sixty pounds before shipment.

Catalogue sent on request.

TITUSVILLE IRON WORKS COMPANY
TITUSVILLE, PA.

New York Detroit Pittsburgh
Chicago Buffalo Washington

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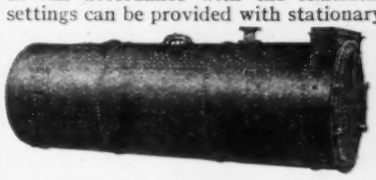
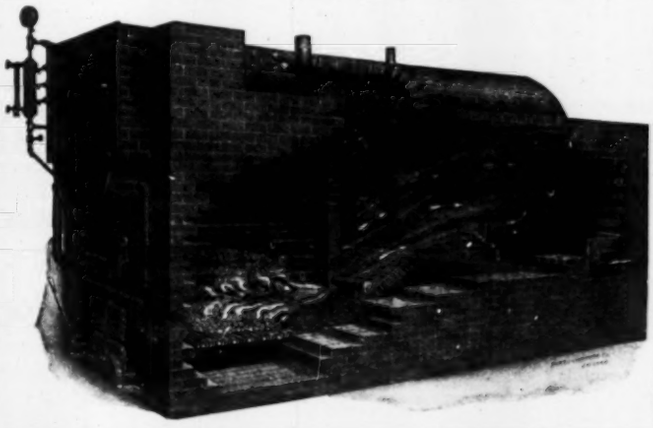
BOILERS

HORIZONTAL RETURN TUBULAR BOILERS

These boilers are constructed of high grade materials in full accordance with the A.S.M.E. Code. Standard settings can be provided with stationary or shaking grates, and when desired, standard steel casings can be provided for these settings. Liberal proportions of heating surface, steam space and grate area. Regularly manufactured in units up to 250 h.p.; and for steam pressure of 200 lbs. per square inch. Further information regarding Cole Boilers, Tanks, Plate Work, etc., will be found on page 49 of the 1922 volume, A.S.M.E. Condensed Catalogues.



R. D. Cole Mfg. Co. Newnan, Georgia



Herbert Smokeless Boilers

Down Draft **Detachable Firebox**

An absolutely smokeless boiler that is guaranteed to consume 95% of smoke from any grade of mine coal and to increase the boiler capacity from 5 to 25 h. p., depending on size.

HERBERT BOILER CO., Chicago

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A.S.M.E. CODE BOILERS

The Casey-Hedges Boilers

are the result of years of experience in the design and construction of all types of boilers. They are built to conform with the standards of the A. S. M. E. Boiler Code—they are safe, economical and durable.

They are efficient and durable

All types of Casey-Hedges Boilers are designed to give the maximum of horse power with the minimum of fuel consumption.

Let our engineering department assist you in selecting your next unit.

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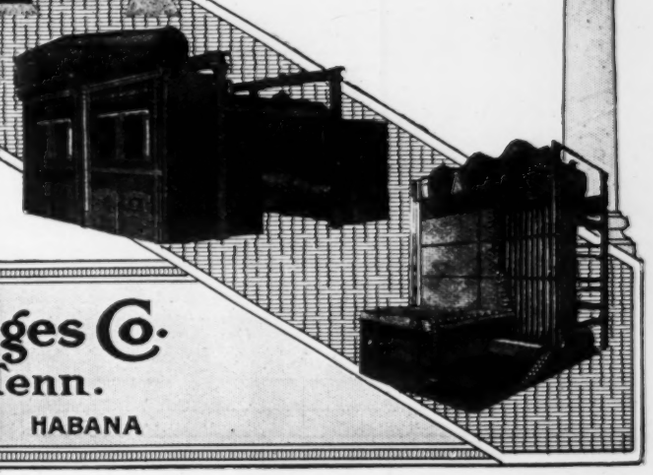
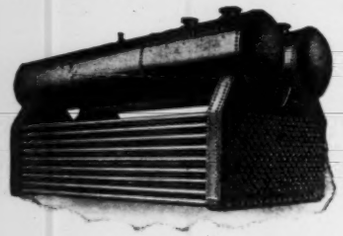
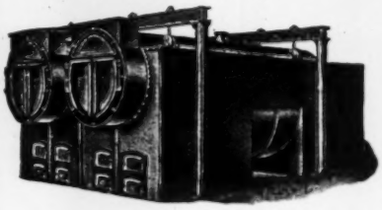


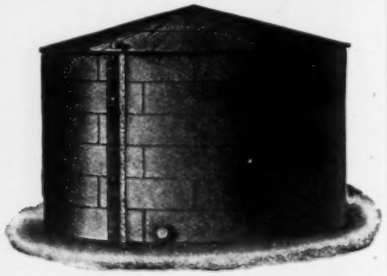
The Casey-Hedges Co.
Chattanooga, Tenn.
CHICAGO NEW YORK HABANA



A.S.M.E. CODE BOILERS



"W & W" Boilers are built — for high efficiency—for high pressure—for high rating.



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All types of "W & W" Boilers are built to obtain the highest efficiency in conjunction with durability and a minimum cost of up-keep.

Before ordering your next unit—let us give you figures.

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Boiler Room Costs!

Use the Coupon

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Gentlemen: Without obligation on my part, I would like to read your educational technical bulletins as checked:

Bulletin 2. The Steam Boiler Analyst.
Bulletin 3. Reducing Costs in the Boiler Room.
Bulletin 4. Magnitude and Prevention of Air Infiltration Losses.
Bulletin 5. Saving Coal in Steam Power Plants.
Bulletin 6. The Utilization of Waste Heat for Steam Generation.

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D A.S.M.E.—22

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WATER TUBE and FIRE TUBE

Design, Workmanship and Materials of the Highest Grade

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See our exhibit at the
NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING
Grand Central Palace, New York
December 7th to 13th

THE GEORGE T. LADD COMPANY

First National Bank Building
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Chicago Office
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New York Office
18 Warren Street

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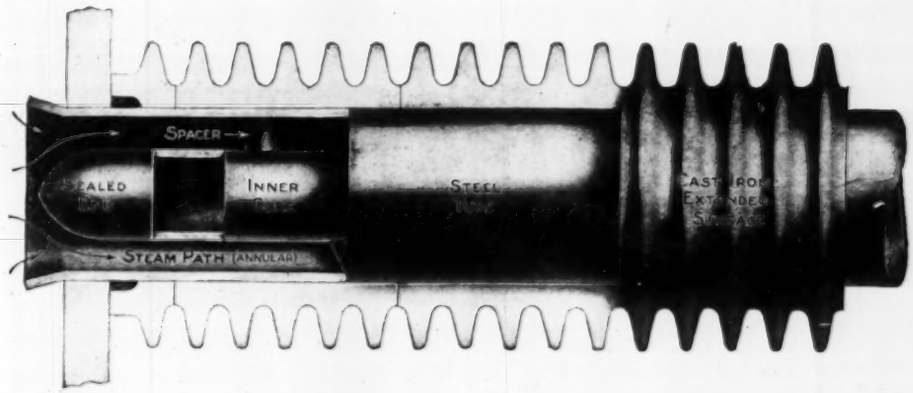

Foster Protected Surface

While a superheater is a relatively small part of a power plant, its reliability determines its continued operation and is therefore important.

The reliability of Foster Superheaters is assured by the well known Foster protected surface, consisting of a steel tube for strength and cast iron protecting rings for ruggedness and greatest possible superheating surface.

The outer cast iron surface not only steadies the degree of superheat obtained, but also prevents burning out of the superheater elements and protects the steel tubes from the corrosive effects of the furnace gases. The protection which it affords is so complete that the life of a Foster Superheater is greater than that of the boiler to which it is attached.

The reliability of Foster Superheaters is being proven daily in thousands of power plants all over the country. Send for the Foster Superheater Book. It explains in detail the benefits of superheat and describes the Foster patented construction that assures these benefits with greatest reliability and least maintenance expense.

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Advantages of Foster Superheaters

1. Steel for strength, cast iron for durability.
2. Four to six times as much heat-absorption surface as obtained from bare tubes.
3. Reserve heat stored for sudden demands.
4. Steam stays close to the hot tube surface.
5. Great flexibility of design.

"The Superheater with the Extended Surface." Over 10,000 installations.

POWER SPECIALTY COMPANY

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FOSTER SUPERHEATERS

35

At Your Service!

THE
A.S.M.E.
BOOTH
No. 80

National
Exposition
of
Power and
Mechanical
Engineering

Grand Central Palace
New York, N. Y.
December 7th to 13th

YOU are cordially invited to visit the A.S.M.E. Booth, Number 80, and make use of the following services:

Rest Room for your comfort.

Stenographer to write your letters.

Mail addressed to the booth will be held until your arrival.

Appointments can be made to meet your friends at the booth.

Information can be had about the Exposition, New York City and vicinity.

Applications can be filed at the booth for membership in the Society.

Publications of the Society will be on exhibition.

American Society of Mechanical Engineers

29 West 39th Street, New York, N. Y.

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SUPERHEATERS
For any size or type boiler—Close temperature regulation.
Send for Bulletin FT-7
THE SUPERHEATER COMPANY
General Offices: 17 East 42nd St., New York
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Branch offices in all principal cities

RADIAL BRICK CHIMNEYS
Designed and Erected
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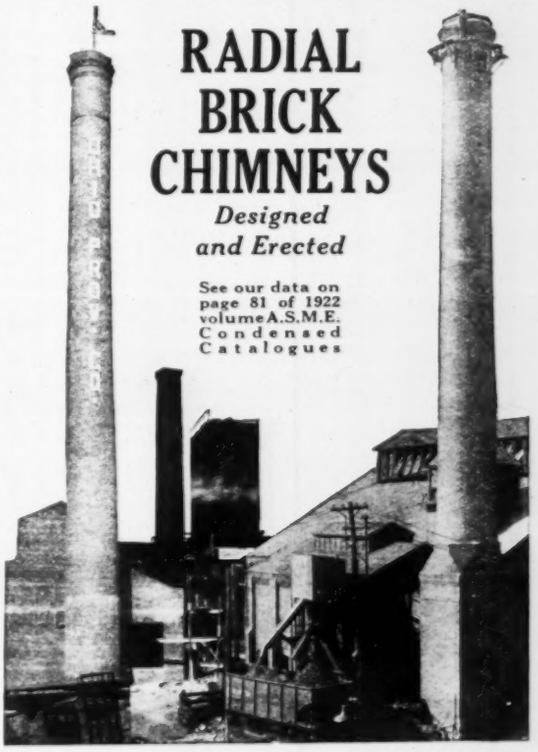

AMERICAN CHIMNEY CORPORATION
147 Fourth Avenue, New York
BOSTON PHILADELPHIA CLEVELAND CHICAGO

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If you desire capital or have it to invest; if you have a patent for sale or development; if you have on hand used machinery for disposal, or if you want such equipment; if you have copies of publications, or a set of drawing instruments to dispose of; in fact, anything to be offered that somebody else may want, or anything wanted that somebody else may have—use a Classified Advertisement in MECHANICAL ENGINEERING for quick results.

...RATES...

40 cents a line; 30 cents a line to members of A.S.M.E. (Minimum insertion, 5 lines; maximum, 20 lines. No display matter carried.)

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
29 West 39th Street New York City

THE BABCOCK & WILCOX COMPANY
85 LIBERTY STREET, NEW YORK

Builders since 1868 of Water Tube Boilers of continuing reliability

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THE BABCOCK & WILCOX COMPANY
STEAM
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Bayonne, N. J.
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Makers of Steam Superheaters since 1898 and of Chain Grate Stokers since 1893

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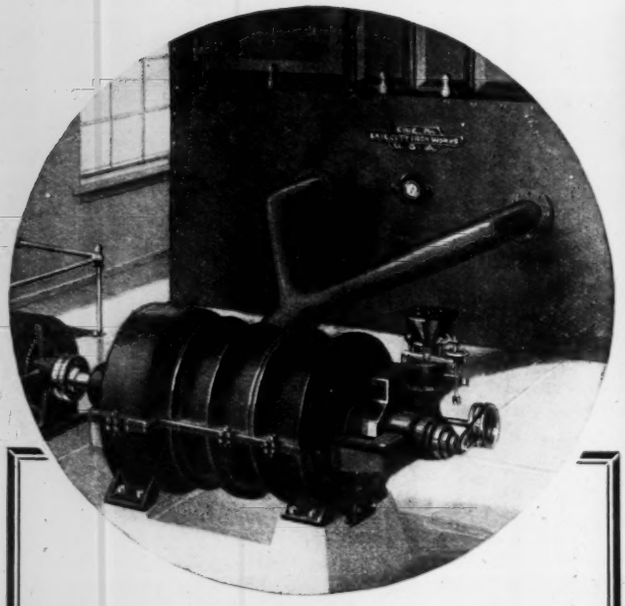


The Use of Pulverized Coal Results in Large Savings

With Erie City Pulverized Coal Equipment it is possible to maintain an overall efficiency of 80% or more. This constitutes a big economy in fuel to begin with. The pulverized coal burns practically like gas or oil. Coals with low B.t.u. content, high in sulphur, and with high or low fusing ash may be utilized.

No pulverized coal is kept in storage—it is pulverized only as used. Changing load demands are taken care of by the perfect flexibility of the system. Smokeless combustion is assured. No clinker or slag troubles. No standby losses. Low draft requirements. Lowest labor cost. No cleaning of fires. Absolute control of CO_2. Low maintenance expense—entire mechanism outside of combustion space. Adaptable to any size plant—all boiler installations. One type of machine for all kinds of bituminous coal. Driven by motor, steam turbine, or provision can be made for driving by means of a belt.

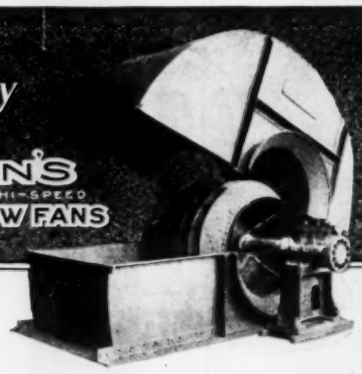
Investigate Erie City Equipment

ERIE CITY IRON WORKS
ERIE, PA., U. S. A.

Manufacturers also of Erie City Water Tube, and Return Tubular Boilers, The Lentz Engine, and other products, as shown on pages 54 and 55 of the 1922 A.S.M.E. Condensed Catalogues.

Save Auxiliary Power

GREEN'S
HI-EFFICIENCY HI-SPEED
RADIAL FLOW FANS



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MECHANICAL DRAFT
GREEN'S
RADIAL FLOW
AND
STEEL PLATE FANS
MEET MODERN BOILER ROOM REQUIREMENTS

BULLETIN No. 127 - - STEEL PLATE
BULLETIN No. 152 - - RADIAL FLOW

(See Our Data in 1922 A.S.M.E. Condensed Catalogues of Mechanical Equipment)

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BEACON, N.Y.

PIPE and FITTINGS
For all uses

BAROMETRIC CONDENSERS

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United States Cast Iron Pipe and Foundry Co.
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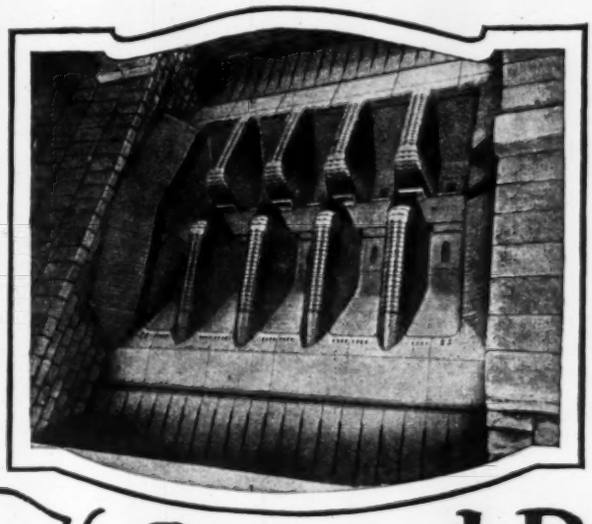


Announcing

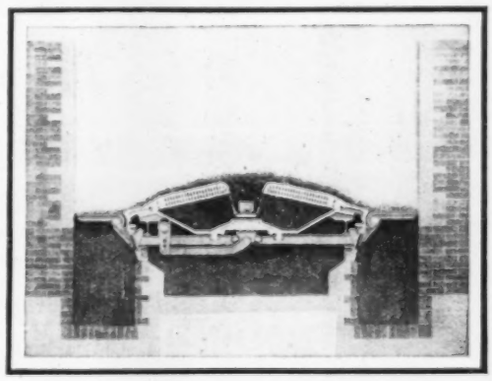
a great advance in stoker building

The Lateral Retort Stoker

TRADE MARK

Multiple retort efficiency with single retort simplicity—that is the gift of the Lateral Retort Stoker to the power plant world

THE view above shows how the multiple retort effect is obtained in an extremely simple way. Coal is fed lengthwise into the main retort by the strokes of a steam operated ram. It is then distributed sidewise into the several lateral retorts. Only two steam cylinders and moving units are used, and the few moving parts are never subjected to the heat of the furnace — yet note how this firing method attains a degree of efficiency never before equaled in a stoker of equal simplicity.



The coal is under-fed throughout. Although a side dump is employed, the fuel is not overfed onto side grate bars as in former side dump stokers. It is under-fed, not only to the main retort, but also to each lateral retort. The advantages of underfeed combustion are retained—distillation of volatiles is slow and thorough; coking is complete. This insures highest combustion efficiency, and the large reserve fuel capacity of the retorts insures heavy overload capacity and ability to handle sudden peak loads.

The coal feed to the main cylinder and to the lateral retorts is controlled separately, insuring an even fuel bed and increased flexibility.

By applying the multiple retort principle to a side dump stoker the necessity for excavation and basement ash pits is eliminated. This makes the installation cost extremely low. Also it makes the stoker adaptable to old boilers without making expensive changes.

How extreme simplicity made possible by this revolutionary basic principle, has produced a high duty multiple retort stoker that can be installed at a moderate cost is told in a new catalogue. Write for it.

SANFORD RILEY STOKER CO.

WORCESTER, MASS.

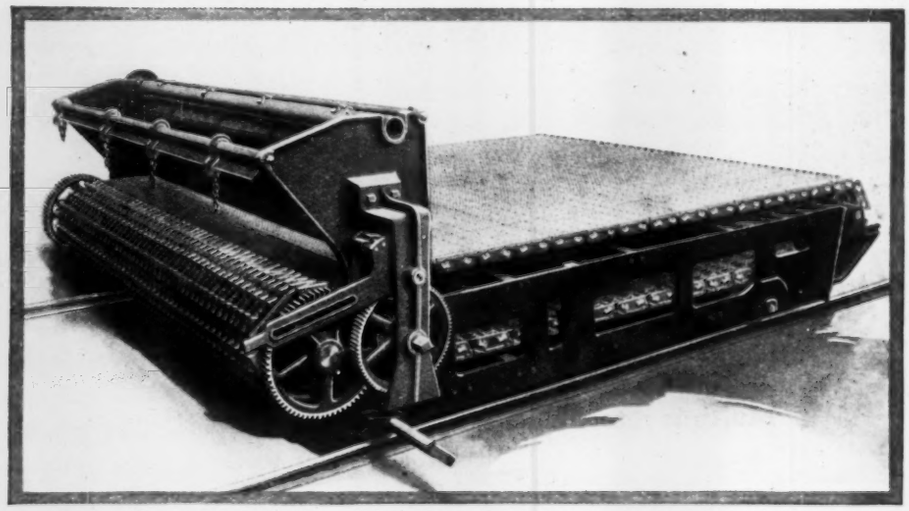
"RILEY" Underfeed Stokers "JONES" Underfeed Stokers

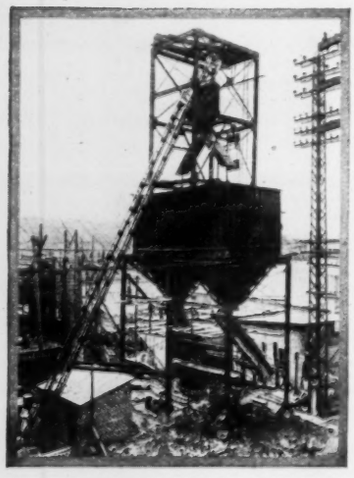
"MURPHY" Automatic Furnaces

BOSTON NEW YORK PHILADELPHIA PITTSBURGH BUFFALO CLEVELAND DETROIT

CHICAGO ST. PAUL THE UNDER-FEED STOKER CO. OF CANADA, LTD., TORONTO DENVER CINCINNATI

A Common Sense Balance





Green Cast-Iron Hoppers

solve the problem of transfer and storage of ash from the boiler room. They are adaptable to practically any plant layout. Easily and quickly erected by unskilled labor. Contents are instantly discharged into truck or railroad car thus eliminating rehandling charges.

INTERNATIONAL COMBUSTION

Green Chain

Means Lower Steam Costs

There are three important factors in steam generation economy:

Maintenance Efficiency Capacity

Low steam costs are dependent upon maintaining the proper balance between these factors.

Green Chain Grate Stokers have established a reputation for producing steam at low cost. They operate upon a common sense balance of Efficiency, Capacity and Maintenance.

We will be glad to show you why Green Chain Grate Stokers are able to produce cheaper steam. Write Dept. A for literature.

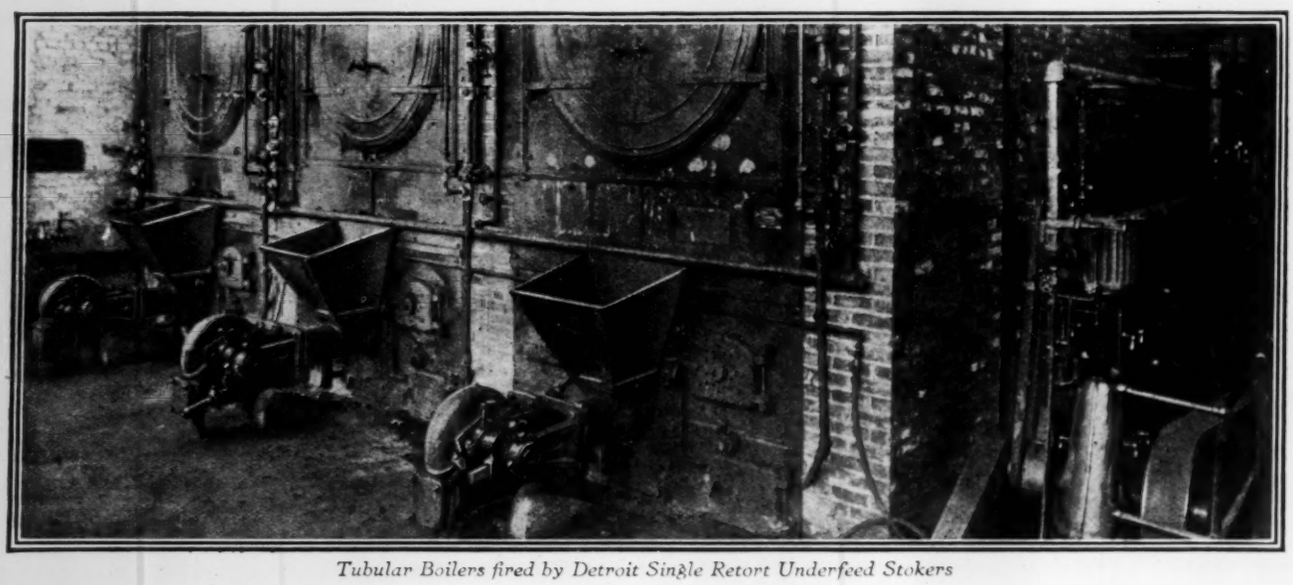
GREEN ENGINEERING COMPANY
70 Kennedy Avenue East Chicago, Indiana

ENGINEERING CORPORATION

Grate Stokers

CHAIN GRATE STOKERS
CAST-IRON HOPPERS
SEALFLEX ARCHES
PRESSURE WATER-BACKS

Detroit Single Retort Underfeed Stokers can be Installed Profitably Under Tubular Boilers



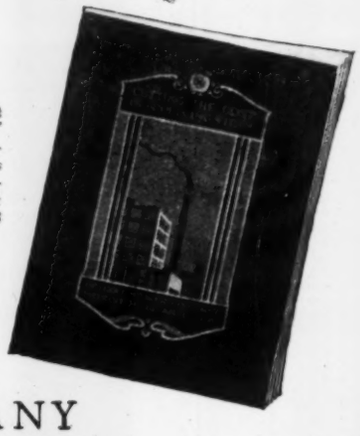
Tubular Boilers fired by Detroit Single Retort Underfeed Stokers

Take the case of two power plants of approximately equal size and capacity. One of them had hand-fired furnaces, under tubular boilers, and the bad conditions of this type of firing had a psychological effect on those working in the boiler room. The place was in a generally ill-kept and unsatisfactory condition. The other plant, which also had tubular boilers, was equipped with mechanical stokers, and, perhaps, because the attainment of efficiency in combustion stimulated the firemen to better work all around, the boiler room was in first class condition. The first plant was using one and one half times as much coal as the second, and because of lack of efficiency in the boiler room, the cost of steam generation was actually twice the cost of production in the second plant.

When stokers were finally installed in the inefficient plant it was found that a cheaper grade of fuel than had previously been used could be burned, and that, due to the uniformity with which the stoker fed the fuel, the proper proportioning of air for combustion, the absence of large amounts of excess air, etc., it was possible to maintain a uniform boiler efficiency of approximately 70 per cent, whereas 55 to 60 per cent had been the rule before. The same amount of steam was generated with considerably less coal.

With the installation of the stokers, a transformation took place in the boiler room. The firemen began to display a hearty interest in their work. As a net result the cost of producing steam in the plant was reduced something like 50 per cent.

Ask for your copy of "Cutting the cost of Producing Steam." It describes Detroit Single Retort Underfeed Stokers and tells the story of the two plants mentioned in this advertisement in detail. Request Bulletin 228



DETROIT STOKER COMPANY

Underfeed Forced Draft and Overfeed Natural Draft Stokers

228 GENERAL MOTORS BUILDING DETROIT, MICH.

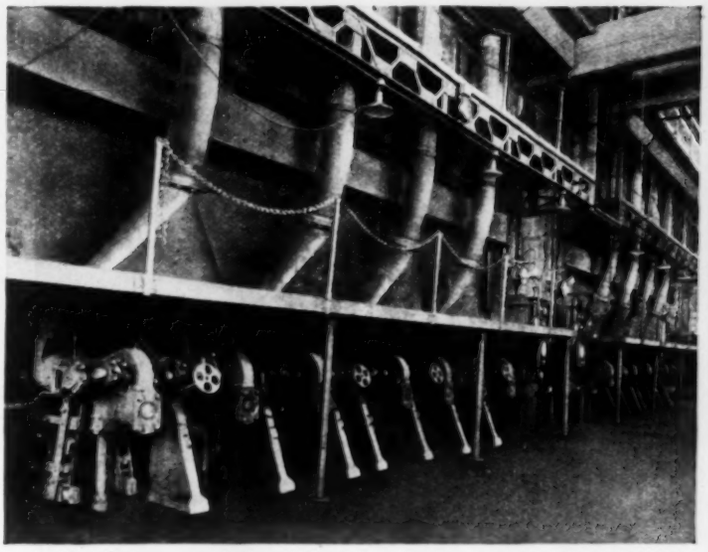
DETROIT UNDERFEED STOKERS

CLEANING THE FIRE

The Taylor Stoker was the first underfeed stoker on which the ashes were discharged at the rear. Coupled with this, it was the first underfeed stoker which automatically cleaned its own firebed.

Notice how many stokers now include this idea.

Firing aisle in the Delaware station of Philadelphia Electric Co. where Taylor Stokers now serve eight boilers of 1508 rated horse power each and four boilers rated at 1427 horse power per unit.



This is one of four large plants in the Philadelphia Electric Co. system supplying light and power to the most concentrated and diversified manufacturing center in the world. Its design is the result of the long experience of the Philadelphia Electric Co's engineers in production of power.

The Taylor Stoker

Has seen service in the various plants of the Philadelphia Electric Company system since 1908, when the first installation was made in the Schuylkill Station. The original installation and repeat orders make the records read like this:

1908—1909—1911—1912—1913—1914—1916—1917—1919—1922

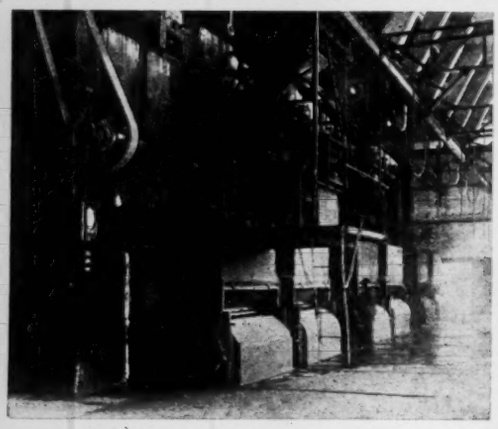
Making a total of 82 Taylors serving more than 76,000 rated boiler horse power.

Money can't buy a better stoker

Ask today for a copy of our new booklet, The Rotary Ash Discharge

American Engineering Company
Philadelphia

Manufactured in Canada by
TAYLOR STOKER COMPANY, LTD., TORONTO, ONT.
Principal Sales Office: 416 *Phillips Place, Montreal, Que.*



efficiency 79.7%

—another triumph for dampered air control

BEAT it if you can—that record of 79.7% efficiency—but use an Illinois Stoker if you really want to succeed!

This remarkable record is the result of a thirteen hour test of two of the six 8 x 12 ft. Type G Illinois Forced Draft Stokers installed under 421 hp. horizontal water tube vertically baffled boilers in the plant of the Imperial Oil Co., Ltd., Sarnia, Canada, as shown in the illustration above.

A heavy snow and sleet storm, accompanied by a freezing temperature, raged throughout the test; yet, when the final calculations were made, there it was in black and white fully supported by complete, accurate entries—a combined efficiency of practically 80%.

This highly significant test raises a question that you should be able to answer:

Could this high efficiency have been attained without the Illinois system of dampered air control—could it have been approached without other equally famous Illinois features?

We'll leave it to you.

The new Illinois Catalog L will help you to arrive at the correct answer. It describes Type A (natural draft) and Type G (forced draft) Illinois Stokers.

ILLINOIS STOKER CO.
102 West 7th Street, Alton, Ill.

Chicago: Ernest E. Lee Co., 115 S. Dearborn St.
Kansas City: J. F. Pritchard & Co., Reliance Bldg.
New York: H. G. Meissner, 141 Broadway.
Indianapolis: R. H. Bennett, 305 Merchants Bank Bldg.
Minneapolis: H. R. N. Johnson, 917A Marquette Ave.
Denver: A. B. Kennedy, Engineer's Bldg.

ILLINOIS CHAIN GRATE STOKERS
With Dampered AIR CONTROL

SIL-O-CEL

PREVENTS HEAT PENETRATION

SIL-O-CEL

Concentration of heat where heat is wanted—

Control of heat where control is needed—

Utilization of heat units for the purpose intended—

These are three of the results accomplished by Sil-O-Cel Heat Insulation.

Sil-O-Cel is a microscopically porous, siliceous material which possesses the lowest heat conductivity of any insulation suitable for high temperatures. Extremely light in weight, it possesses great structural strength and can be furnished in forms which stand without shrinkage direct heats of 2200° F.

Brick, block, powder, cement,—a form of insulation for any type of heated equipment without change in design.

Write nearest office for complete information given in Bulletin H-6 C.

CELITE PRODUCTS COMPANY

New York-11 Broadway Chicago-35 W. Jackson Blvd. San Francisco-Monadnock Bldg.
Baltimore · Boston · Buffalo · Cincinnati · Cleveland · Denver · Detroit
Los Angeles · New Orleans · Philadelphia · Pittsburgh · St. Louis
CELITE PRODUCTS LIMITED, New Birks Bldg., Montreal, Canada

SIL-O-CEL

McClave Grates Save Fuel and Maintenance the Better to Serve Every Industry

McClave GRATES STOKERS STEAM BLOWERS

Made of selected and tested materials in the McClave-Brooks Company's plant and according to the rigid McClave standards, every McClave Grate or other combustion appliance is so designed and so made that it shall render the utmost in service to the user with maximum economy in fuel and maintenance.

Write for catalog.

McCLAVE-BROOKS COMPANY

Makers of the famous McClave Grates since 1883

Scranton, Pennsylvania

BRANCH OFFICES:

New York Philadelphia Boston Detroit Chicago
Greenville, S. C. Kansas City St. Louis Jackson, Miss.
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Salt Lake City Owensboro, Ky. St. Paul

JACKSON RAILWAY & LIGHT CO.

JACKSON, TENN.

May 27, 1922.

McClave-Brooks Company,
Scranton, Pa.

Gentlemen:-

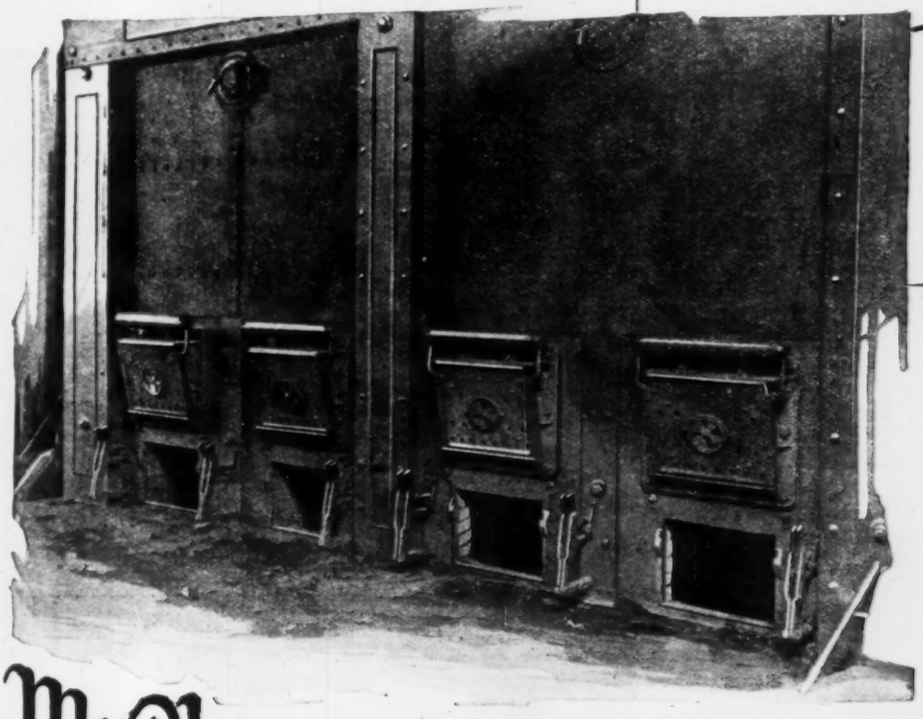
For the past ten years we have used McClave Grates exclusively under all boilers in our Power Station.

These grates have given us most excellent results in the way of fuel saving, service, and low maintenance.

At any time that we purchase new boilers it is our intention to equip them with McClave Grates.

Yours most respectfully,

GENERAL SUPERINTENDENT.



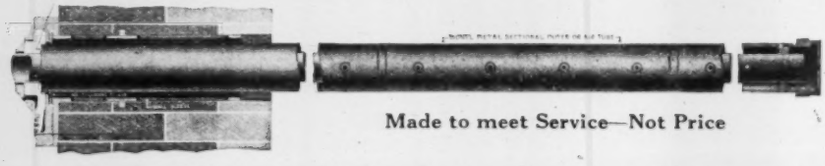
Boiler room in power station of the Jackson Railway & Light Company, Jackson, Tenn., John Wisdom, General Superintendent. Sets of McClave 2-A Grates under two 508 H. P. Sterling Boilers. Two additional sets are under two 200 H. P. Vogt Boilers in the same plant.

McClave COMBUSTION SYSTEMS *for greater economy*

The BAYER TYPE "S"

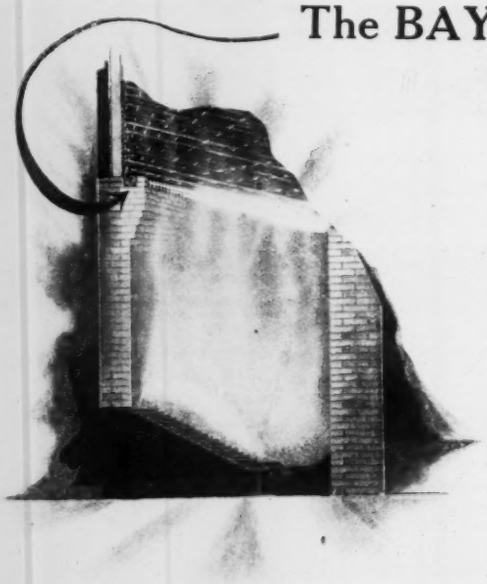
Non-Warpable, Monel metal, Sectional Air-Cooled, Soot Blower Unit

Valve-in-head-Geared-Full Floating



Made to meet Service—Not Price

The BAYER is the only unit that will stand up in this hot spot!!



Encased in its air tube housing and protected by cool circulating air, the steam element snugly awaits commands to rid the boiler of soot. It is not affected by the raging, deadly, destructive high temperatures, because of the air space between the two tubes. Further, its sectional construction allows for any expansion or contraction, thus preventing warping.

Bayer equipment is fully covered by patents allowed and pending.

To such users of the revolving type of mechanical soot blowers who are experiencing trouble with their elements located in high temperatures, we invite correspondence with a view of replacing such elements with the Bayer Non-Warpable, Indestructible, Sectional, Air-Cooled Soot Blower Unit which will eliminate much annoyance, expense and maintenance.

THE BAYER CO.

4068 Park Ave. St. Louis, Mo. U.S.A.

We have openings in several localities for top notch representatives

Mail coupon for booklet and complete information on our Type "S" Non-Warpable, Monel metal, Sectional, Air-Cooled Soot Blower Unit, to THE BAYER COMPANY, 4068 PARK AVE., ST. LOUIS, MO.

Name..... *Kind of boiler*.....

Address..... *Business*.....

M.E.12-22

Automatic Valved Soot Blowers

Diamond "VALV-IN-HEAD"

We are the originators of soot blowers having valves automatically operated by the rotation of the blower which construction is covered by patents, issued and pending, owned by us. Infringements of these patents will be prosecuted.

DIAMOND POWER SPECIALTY CORPORATION
DETROIT, MICHIGAN, U.S.A.

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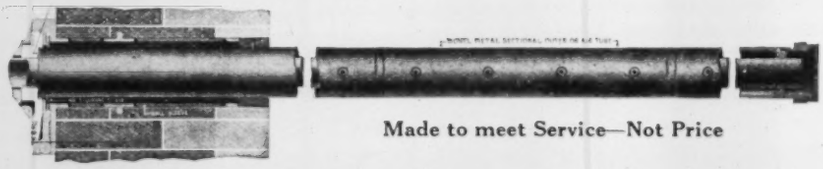
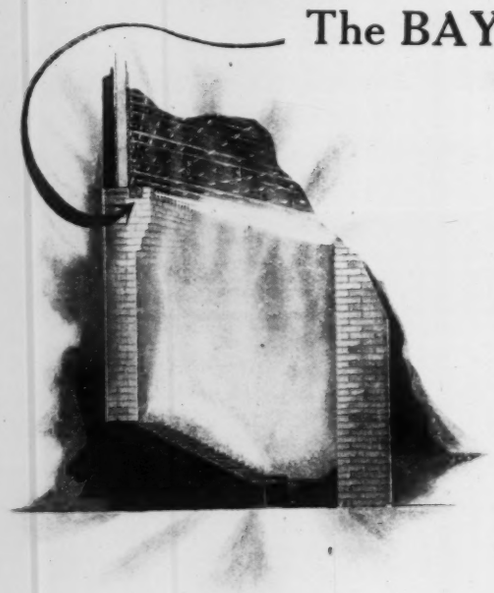
Non-Warpable, Monel metal, Sectional Air-Cooled, Soot Blower Unit

Valve-in-head-Geared-Full Floating



Made to meet Service—Not Price

The BAYER is the only unit that will stand up in this hot spot!!



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We have openings in several localities for top notch representatives

Mail coupon for booklet and complete information on our Type "S" Non-Warpable, Monel metal, Sectional, Air-Cooled Soot Blower Unit, to THE BAYER COMPANY, 4068 PARK AVE., ST. LOUIS, MO.

Name..... *Kind of boiler*.....

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We are the originators of soot blowers having valves automatically operated by the rotation of the blower which construction is covered by patents, issued and pending, owned by us. Infringements of these patents will be prosecuted.

DIAMOND POWER SPECIALTY CORPORATION

DETROIT, MICHIGAN, U.S.A.

COAL

PARDEE WEBSTER

HOW much would it be worth to you to know that your coal will be delivered this winter when needed?

And in addition to know that it will be of highest quality, for the particular conditions under which it is to be used?

A "Pennsylvania" contract will relieve you of worry; and possibly save you the payment of premiums.

PENNSYLVANIA COAL & COKE CORPORATION

Pardee and Webster Steam Coals
Webster Selected Smithing Coal

17 Battery Place, New York

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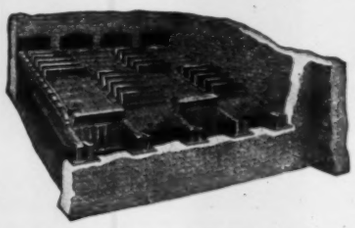
FILES HAND STOKERS



Always the most efficient.

Recent improvements in design and construction make this stoker the most durable. Ask us for the proof.

GIBBY ENGINEERING COMPANY
East Boston, Mass.

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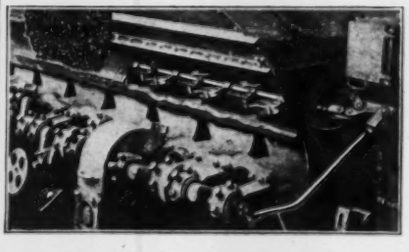
NEGUS-TIFFANY COAL AGITATORS

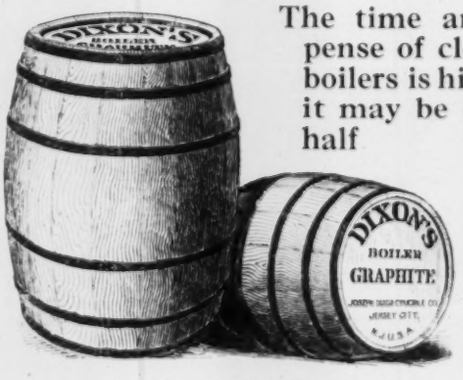
WILL CURE YOUR WET COAL TROUBLES

and increase boiler efficiency at all times



Saves Coal
Saves Labor
Saves Breakage
Saves Money
Saves Cussing

W. E. ELLIS CO.
Haverhill, Mass.



The time and expense of cleaning boilers is high but it may be cut in half by using

DIXON'S BOILER GRAPHITE

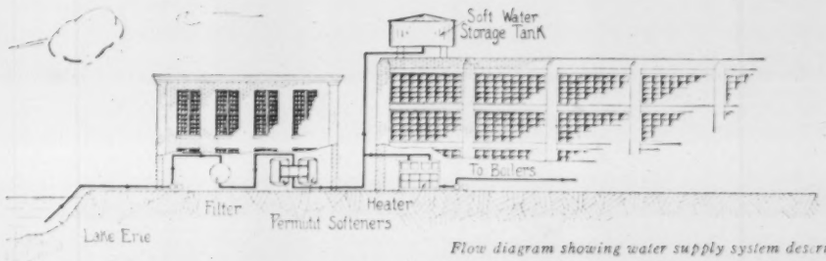
The action of graphite is mechanical—not chemical and it does not attack the metal. It is not affected by acid in the water or heat in the boilers.

Graphite particles work their way through the fissures in the scale and penetrate between the scale and the metal. The scale thus loosened may be easily removed.

Dixon's Boiler Graphite is a common-sense treatment for scale, Safe, Economical, Efficient.

Write for Booklet No. 160T
"Graphite for the Boilers"

JOSEPH DIXON CRUCIBLE CO.
JERSEY CITY, N. J.
Established 1827



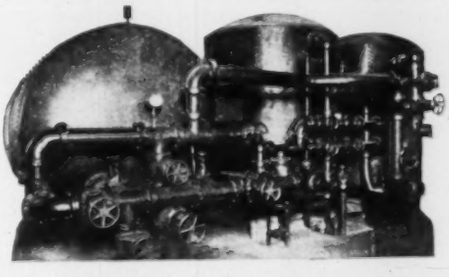
Flow diagram showing water supply system described below.

Not a Single Boiler Tube Replaced in 4800 H. P. Boiler Plant Since 1920

A large industrial corporation in Buffalo, N. Y. operates a boiler plant consisting of 6 Sterling, vertical water tube boilers that develop an average of 4800 H. P., 24 hours per day the year round.

The water supply used for boiler feed purposes is derived from Lake Erie, and besides having variable amounts of sludge and mud forming matter, contains an average of 8 grains of hardness per gallon.

Due to the steady demand for continuous service from these boilers, which are operated day and night without a letup, it is absolutely essential that they be free from scale, sludge and mud, as an interruption in service to replace or clean boiler tubes would be very costly.



Photograph of Permutit water softening plant described above. Note small size and simplicity of the installation.

With this in mind a Permutit zeolite water softening system was installed in September 1920 when the plant was built. It delivers 230,000 gallons of absolutely clean, zero soft water per day, and during the two years it has been in service it has completely prevented the formation of scale, sludge and mud in the boilers or their connections.

A letter from the vice president of the corporation states in part—

"... recently we opened a boiler after nine months' continuous service and found no scale of any character on the tubes ..."

"... we have not as yet replaced a tube after one and one-half years of operation."

In this large boiler plant, operating at heavy loads day and night, there are no cleaning gangs employed, no boiler shut-downs, no tube replacements—and there have been none since the plant was built in 1920.

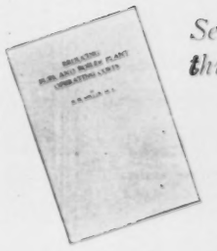
How about YOUR boiler plant? Let us solve your problems too. Write for our valuable booklet today.

The Permutit Company
440 Fourth Ave. New York

Zeolite Water Softener Patent Sustained

The Federal Court at Buffalo (Hazel, J.) on June 15th, 1921, handed down a decision sustaining our broad patent covering Zeolite Water Softeners which has been affirmed by the Court of Appeals. According to this decision all Zeolite Water Softening Apparatus on the market not made by us is an infringement of this patent.

No need to borrow trouble — buy Permutit—it is the best anyway.



Send for this free booklet

The Permutit Company
440 Fourth Ave.
New York

Please send me your free booklet, "Reducing Fuel and Boiler Plant Operating Costs."

Name .....

Address .....

Company .....

See Our Data in 1922 A.S.M.E. Condensed Catalogues of Mechanical Equipment

The same old story over and over again—

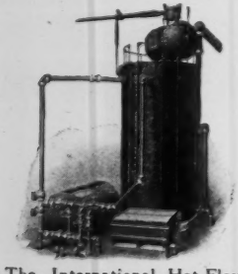
DOES it pay? Can you possibly justify the endless attack on scale? Turbining and other methods of mechanical scale removal are merely an admission that you *do* countenance scale in your boilers.

Scale increases after cleaning periods and reaches the peak of heat insulation before cleaning periods. The average insulation can be reduced only by extremely frequent cleanings, in which case labor and shutdown costs exceed the saving gained in fuel economy.

Chemical compounds are another admission that softened water is needed, and the sludge formed and frequent blow offs required, are proofs that compounds are only a makeshift remedy for scale troubles.

Are you justifying these methods on a basis of cost? Are you under the impression that these makeshift methods save money as compared with the International Hot-Flow Water Softener? If so, you should make some cost comparisons.

We have outlined the items that should be compared. You do the comparing. Would you like to have a blank to fill out that will put the dollar and cents side of the boiler scale problem clearly before you? Then pencil a request to—



The International Hot-Flow Water Softener supplies boilers with the equivalent of hot rain water. Such feed water can form *no* scale.

International Filter Co.
WATER SOFTENING AND FILTRATION PLANTS
Works and General Offices:
333 W. 25th Pl., Chicago
New York Pittsburgh Buffalo San Francisco
Canadian International Filter Co., Ltd., Confederation Life Bldg., Toronto.

INTERNATIONAL
WATER SOFTENERS

SPRACO
Full Cone Spray Nozzles

as used in Spraco cooling pond systems produce finer drops, more uniform distribution and greater cooling results than any other device of its kind now on the market.

Send for Catalogue C-22

SPRAY ENGINEERING CO., Boston, Mass.

Manufacturing also Air Washers, Spraco Paint Guns, Spraco Nozzles and Strainers, Vaughan Flow Meters, Etc.

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UNISOL

REG. U. S. PAT. OFF.

Daily blowing down, and the proper use of UNISOL, gradually removes boiler scale, prevents scale formation, stops and prevents corrosion and pitting, and removes grease from steam boilers.

Pamphlet on request. Money back guarantee.

UNISOL MFG. CO. Jersey City, N. J.

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November, 1922 CARD INDEX Vol. 44, No. 11

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WATER
WE-FU-GO AND SCAIFE SOFTENING SYSTEMS

Scaife Standardized Softened Water For Boiler Feed and all Industrial Uses

Scaife Filters for all Purposes

NEW YORK: 26 Cortlandt St.; CHICAGO: First Nat'l Bank Bldg.

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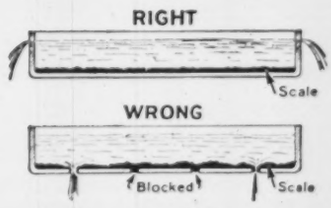
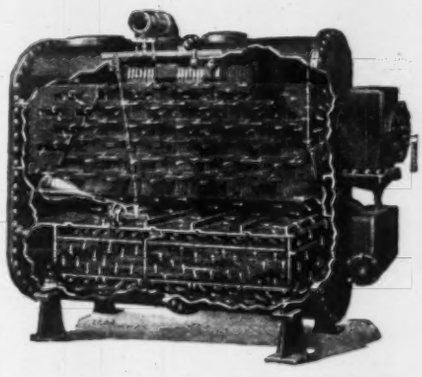
WM. B. SCAIFE & SONS CO. PITTSBURGH, PA.



Pans Can't Clog

It is impossible for the pans of a Worthington - Stilwell Feed Water Heater to block or clog. The water flows over notches in the tray flange, and not through holes in the bottom of the pan. Scale deposit simply settles in the bottom of the pan and does no harm. The water is always broken up into the proper number of streams irrespective of lime deposits.



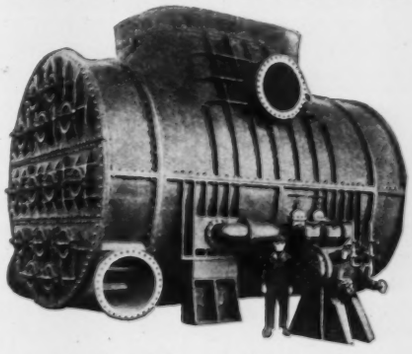
Worthington-Stilwell open feed water heater.

WORTHINGTON

WORTHINGTON PUMP AND MACHINERY CORPORATION

Executive Offices: 115 Broadway, New York City. Branch Offices in 24 Large Cities W 102.4

A WHEELER CONDENSER INSTALLATION IS A TRUE ECONOMY



First cost is always a consideration in buying any apparatus but a more important consideration is the question of upkeep and operating expense.

Upkeep and operating expense rather than first cost are the reasons why "one who knows" buys Wheeler Condensers.

Send for Catalog 112-C on "Wheeler Condensers."

WHEELER CONDENSER & ENGINEERING CO.

CARTERET, N. J.

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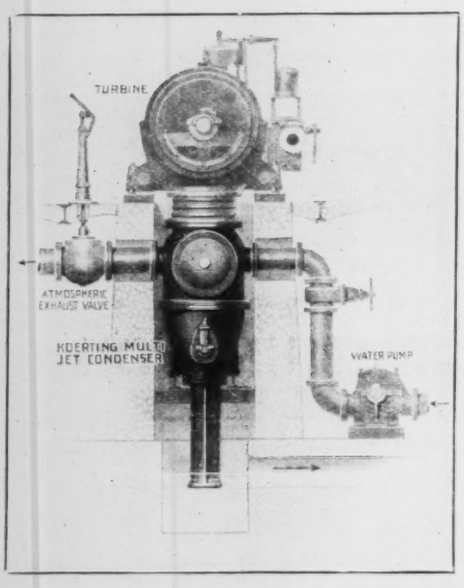
See our Exhibit at Exposition of POWER & MECHANICAL ENGINEERING, GRAND CENTRAL PALACE, NEW YORK CITY, Dec. 7th to 13th

Carry a High Vacuum Without An Air Pump



KOERTING
Multi-Jet CONDENSERS

Simple to install and operate.
Positive and reliable in service.

Built in 30 standard sizes from 100 to 10,000 kw. capacity.

Address Condenser Department.

SCHUTTE KOERTING
1166 THOMPSON STR
PHILADELPHIA·PA

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SPRAY POND

VERSUS

COOLING TOWER— *which?*

Which type of water cooling device is better for your plant?

The answer depends on the nature of the duty, the climate, and the amount and value of available space.

No sweeping claim of superiority for either type can be justified in the absence of specific information covering plant conditions.

We investigate, then quote you on best type for your particular service.

THE COOLING TOWER CO., INC.
17 John St., New York

COOLING TOWERS AIR WASHERS
SPRAY NOZZLE SYSTEMS

Write for Catalogue 9A

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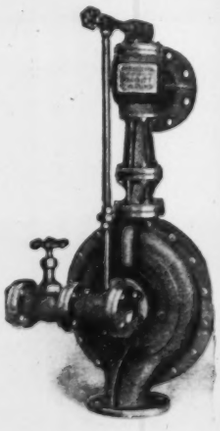

Steam Actuated

Radojet Air Pump

(*Patented*)

Can be operated efficiently and economically with high or low pressure steam.

Over 6 million H. P. sold.

Surface and Jet Condensers for all service.

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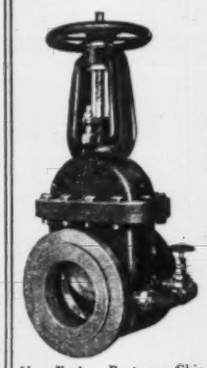
C. H. Wheeler Manufacturing Co.
Main Office and Works: Philadelphia

BRANCHES:
New York Boston Chicago Pittsburgh Charlotte
San Francisco Seattle



KENNEDY VALVES

have stood the test of time. Their superior features have been proven by efficient service from year to year. There is no necessity for experimenting when buying valves.

Send for the Kennedy Catalogue and keep it on your desk

KENNEDY VALVE MFG. CO.

ELMIRA, N. Y.
Export Office:
Elmira, N. Y.

New York Boston Chicago San Francisco Seattle El Paso Salt Lake City

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ASHTON

POP VALVES and GAGES

Recognized for their absolutely dependable quality.

Used in the leading high pressure power plants.

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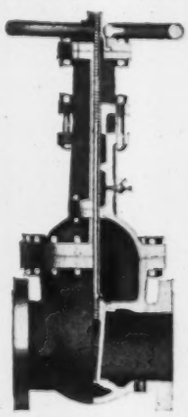

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Whatever Your Needs

May be in the line of Hydraulic machinery or Hydraulic fittings, WE CAN FILL THEM.

Not only can we supply the style of press you desire but we can back it up with forty-five years of experience in the building of Hydraulic equipment.

In most cases we can supply presses of standard design. However our staff of engineers are at all times capable of producing presses for special requirements.

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Vogt DROP FORGED FITTINGS

There is a Vogt Drop Forged Steel Valve and Fitting for every need where high pressures or temperatures in oil, gas, air, water, ammonia, steam and super-heated steam are used. The drop forging method used in the production of Vogt Fittings, makes strength their dominant feature. Let us quote on your valve and fitting needs for high pressure and temperature work.

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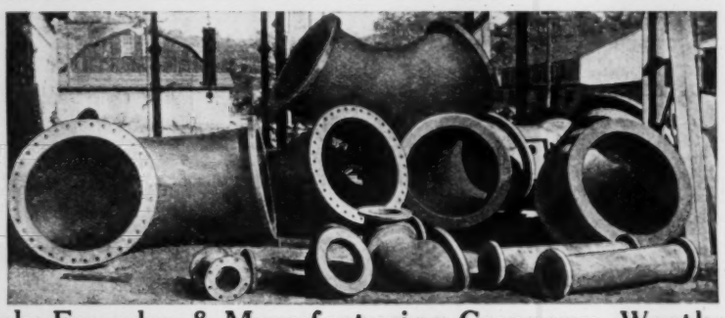
Up in the Lehigh Valley—just far enough from the Metropolitan Section to make certain definite economies possible—is a big well-equipped plant devoted entirely to the production of castings, forgings, and general machine work on a contract basis. Castings can be handled up to twenty tons in weight—forgings up to 12 inches in diameter—



and we can machine anything we cast or forge.

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CAST IRON PIPE THAT MAKES ITS OWN JOINTS

—no packing, no calking, nothing to deteriorate. Tight—flexible—dependable. Used the country over for water, gas and other service where freedom from leakage is essential.

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H. GORDON BRINCKERHOFF CO.

Manufacturers Representative for products having unusual features or exceptional excellence that conserve fuel, labor, or industrial costs.

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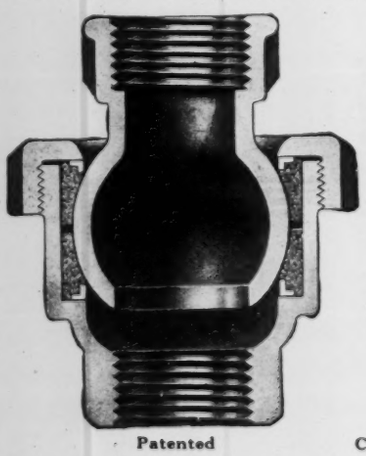
Barco Flexible Joints
For

Use wherever a Flexible Connection is required for high or low Pressure, Steam, Vacuum, Water, Oils, Benzines, Naphtha, Air and Gas, in place of Rubber or Metallic Hose, Expansion Joints, Special Pipe Bends, etc. All styles, Straight, Angle, Male, Female, and Flange ends.



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TAYLOR'S SPIRAL RIVETED STEEL PIPE

Taylor's Spiral Riveted Steel Pipe is furnished with FORGED STEEL FLANGES attached. These flanges expand evenly with the pipe, and cannot be broken by any possible condition that may arise in the piping system.

SHEET STEEL FITTINGS are made according to your special designs to meet the most difficult or unusual conditions.

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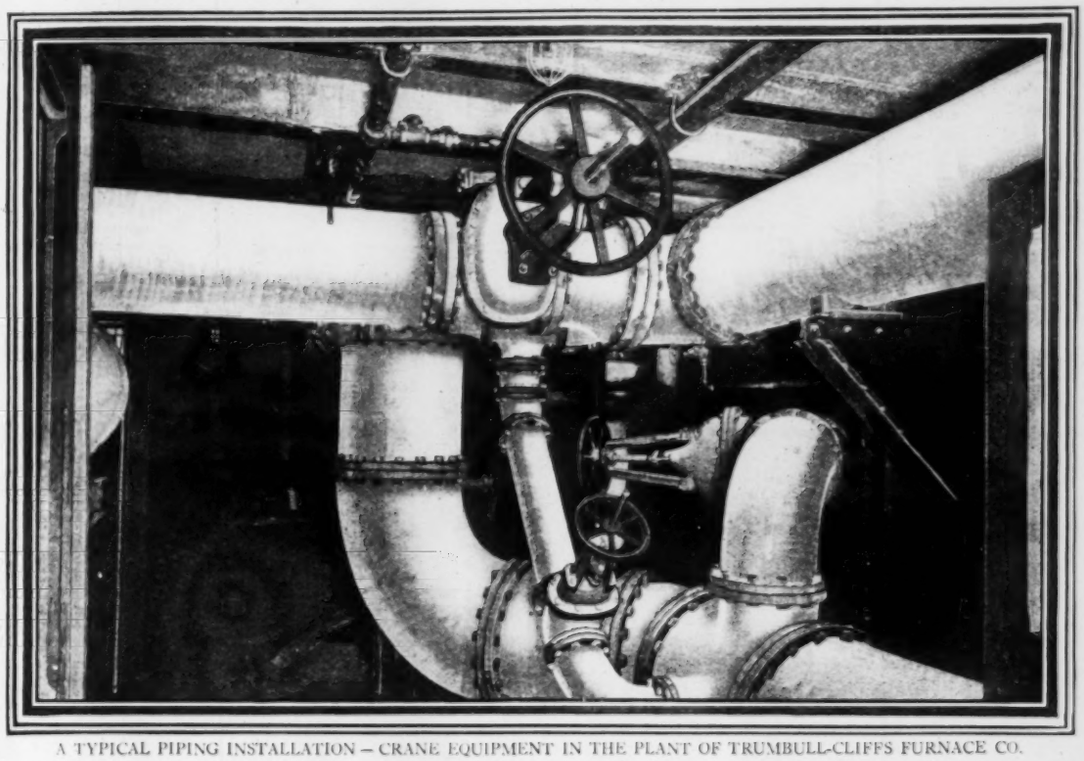

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Lower upkeep expense for piping systems depends on uniform quality in all equipment used. For a pipe line is an assembly of many units and the stability of the whole demands unfailing service from each unit—valve, fitting, piping, flange or specialty.

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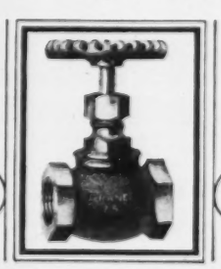

Crane 75 Low Pressure Globe Valve

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STEAM SPECIALTIES

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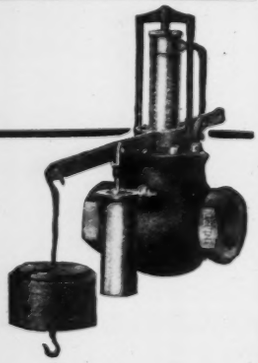
Lasts longer —serves better



—BECAUSE it has no diaphragms or springs to fail and cause trouble—

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—BECAUSE it operates on the infallible principle of the simple balanced scale—

Davis Regulators, like all other time-tested Davis Valve Specialties, give a remarkably better service over an unusually long period.

Write the G. M. Davis Regulator Co., 439 Milwaukee Ave., Chicago, for information about the regulator and other Davis Valve Specialties which include Davis Water Control Valves, Back Pressure Valves, Balanced Valves, Stop and Check Valves, Flow Regulators, Float Valves, Steam Traps, Relief Valves and many other better valves.

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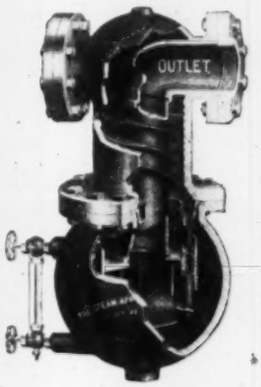

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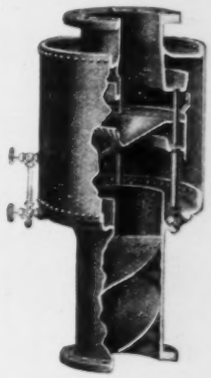
Representatives: We have a very interesting proposition for a few aggressive representatives. Write for details.



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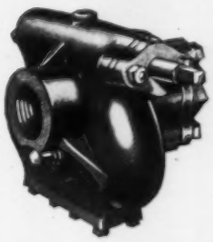
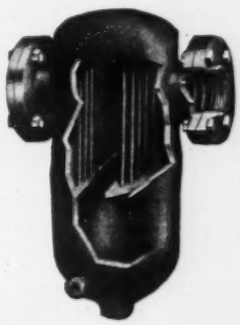
(Horizontal Type)

Guaranteed to deliver water of condensation 99.995 per cent pure.

Ward Blow-Off Valve

Adaptable to stationary, locomotive and marine service. Operates by means of worm gear movement permitting gradual opening and closing with minimum energy, thus preventing all unnecessary strains on boiler and piping. Valve disc never leaves its seat—hence no dirt or scale can lodge in the valve.





Triumph Oil Separator
(Vertical Type—Ascending Current)

This separator performs the difficult work of eliminating oil from exhaust without attention or expense after installation.

Victor Horizontal Separator
(For Steam or Oil)

This separator is guaranteed to deliver water of condensation sufficiently free from oil so that it may be used without danger for boiler feed or laundry purposes.

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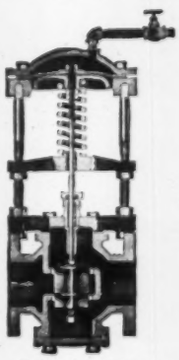
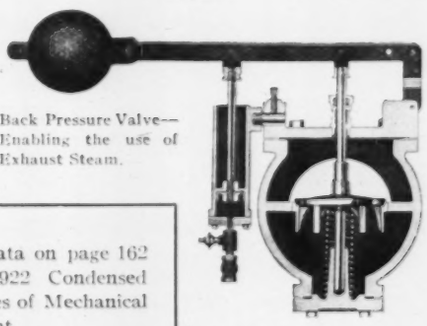
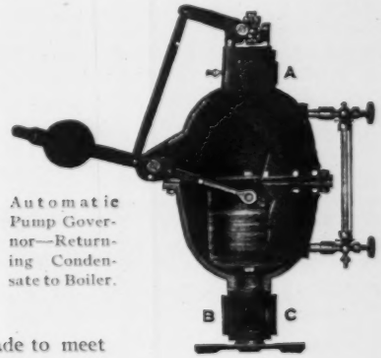


Reducing Valve—from High to Low Pressure



Back Pressure Valve—Enabling the use of Exhaust Steam.



Automatic Pump Governor—Returning Condensate to Boiler.

See our data on page 162 in the 1922 Condensed Catalogues of Mechanical Equipment.

All our equipment is made to meet the demands of modern power plant installations.

Details and prices on application

The Kieley & Mueller Co., Inc. 34-38 West 13th Street, New York City

A partial list of our automatic steam specialties

Beginning at the boiler with the **Non-return Pilot Valve** that closes in case of rupture to either power piping or boiler.
High and Low Water Alarm indicating when not enough water or two much is in the boiler.
Feed Water Controlling Device to maintain constant water level in high pressure boilers.
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Combination for controlling engine and draft for mechanical stoker fired boilers.
Steam Separators and Traps.
Oil Separators and Grease Traps.
Back Pressure Valves, enabling the use of exhaust steam for heating purposes.
Pump Governor to return condensation from high and low pressure returns direct to boilers.
Exhaust Heads, Blow-off and Drip Tank Controllers.
Temperature Controller for hot water tank.
Combination Pump Governor and Lever Float Valve for keeping water supply tank filled.
Low Pressure Boiler Water Feeders and Damper Regulators.
Lifting and Return Traps to return condensation back to boiler where radiators or coils are set below same.

A Float that doesn't Collapse

The float in ordinary steam traps is the cause of much trouble and expense. Made of thin, flimsy metal, they will not withstand high steam pressures without caving in.

The American Ideal Trap has a heavy Hercules float made of seamless, non-corroding copper. It will resist pressures up to 600 lbs. to the square inch and is *guaranteed* for the life of the trap.

But in spite of its heavier construction, this float responds instantly to the slightest rise in the level of the condensate because of its powerful valve leverage.

AMERICAN IDEAL STEAM TRAP

keeps lines thoroughly drained at all times.

If you select your American Ideal Steam Trap on the basis of its guaranteed capacity in accordance with our tables, you will be surprised to find how completely your trap troubles will be overcome.

Size for size, American Ideal Steam Traps handle much more condensation than ordinary traps, and on this basis and length of service, the American Ideal is the cheapest trap on the market.

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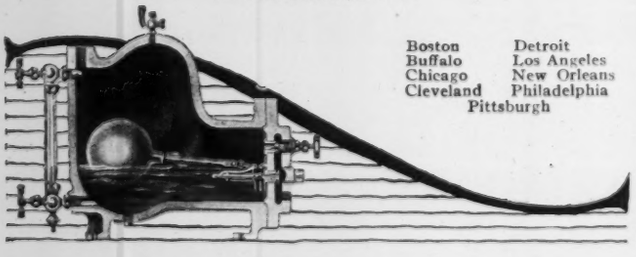

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TIGHT under all conditions

Try them on a 90 day trial basis

Goetze Gaskets are fully described on page 193 of the 1922 volume of the Condensed Catalogues of Mechanical Equipment.

Goetze Gasket and Packing Company
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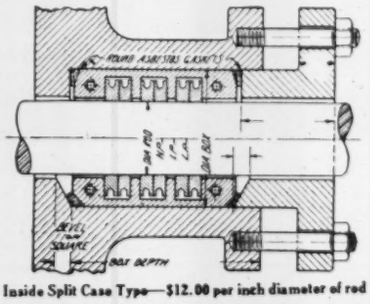

Inside Split Case Type—$12.00 per inch diameter of rod

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CUTTING OIL—FILTRATION—STERILIZATION—CIRCULATION

We DESIGN, MANUFACTURE AND GUARANTEE Cutting Oil Purification Systems to operate under any and all conditions!

Our experience in the manufacture and installation of cutting oil systems—the fact that we have designed and installed the largest systems in the automotive industries and others—places us in position to know the proper equipment to furnish under varying conditions.

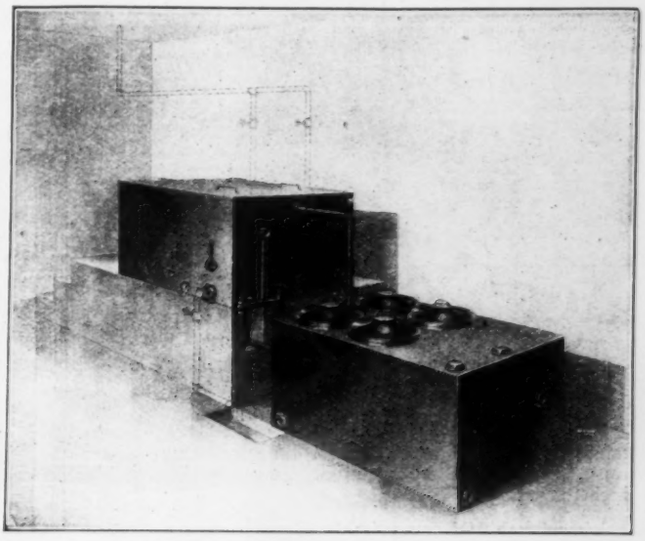
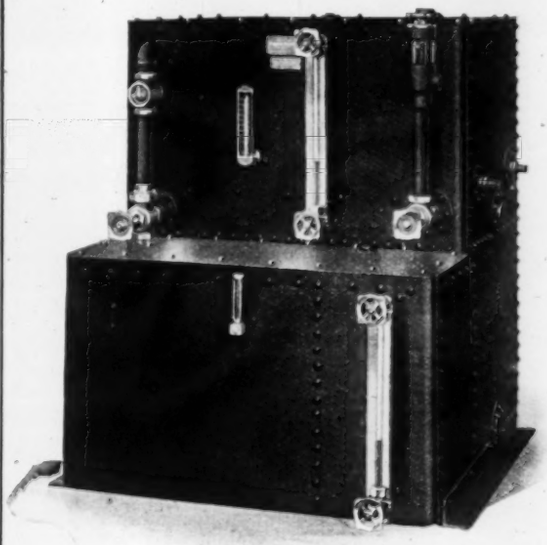


Fig. 9-F Cutting Oil Filtration and Sterilization System.



Type B Filter and Purifier.

No plant is too small—None too large. Our line of equipment is so flexible that the proper combination of standardized units may be made in most cases. Special equipment can and will be furnished when necessary.

The readers of Mechanical Engineering appreciate the advantages to be attained by the installation of cutting oil purification systems—lengthened life of machine tools, increased production, high quality work, improved working conditions.

We have manufactured the largest cutting oil systems in America.

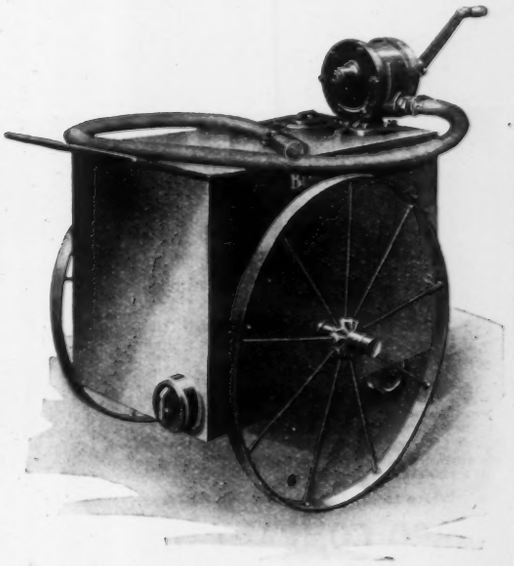


Fig. 182 Cutting Oil Wheel Tank, for use in emptying and refilling individual reservoirs on various machines.

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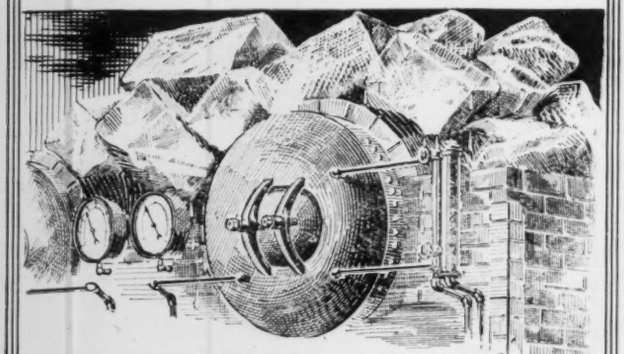
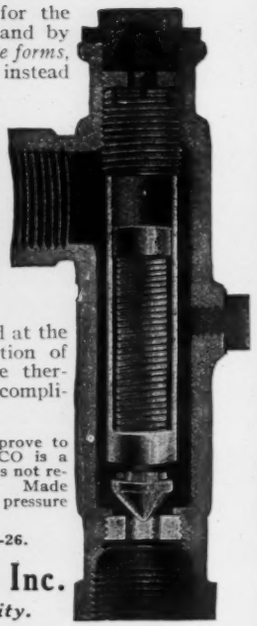


Keep Your Boiler Packed with Ice

By packing ice around your boiler you will reduce the temperature. This makes it more difficult to keep steam up. More coal will be required. Your fuel bills will be higher.

Ridiculous? Of course it is! But not any more ridiculous than the practice of trapping steam lines a hundred feet or more from the point where steam is used. Every foot of pipe that contains condensate is a foot of pipe that cools steam off and wastes coal. Get rid of the condensate *where it forms, instead of at distant points,* and cut down this waste. It requires more traps to do this, but the cost is comparatively light when your lines are fitted with the low-priced

STEAM TRAP SARCO



You can buy three Sarcos for the price of one bucket type trap, and by placing them *where the condensate forms,* you can draw it off instantly, instead of allowing it to drain back through enormous lengths of pipe, chilling the live steam in its progress. 4.T.6

Despite its small size, the Sarco is a little giant for performance. It drains the condensate off as rapidly as it forms, returning it instantly to the hot well without loss of heat units.

Many engineers have marveled at the simple but scientific construction of the Sarco—the highly sensitive thermal element—the absence of complicated parts.

A 30-DAYS' FREE TRIAL will prove to you that the STEAM TRAP SARCO is a money saver. Quickly installed; does not require pit-digging or platform building. Made in sizes 3-8 in., to 3 in. for any given pressure up to 200 lbs.

Write today for Booklet No. E-26.

SARCO COMPANY, Inc.

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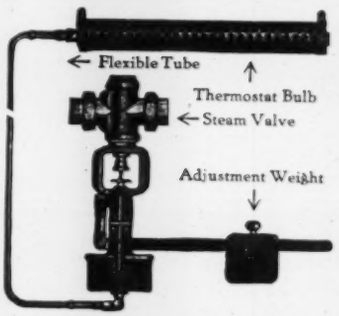
You Don't Guess Time! Why Guess Temperature?

Whenever there is need for maintaining a definite even temperature—the Powers Automatic Heat Regulators give "100 per cent perfect" results. They are always on the job—accurate, sure, reliable. They prevent **all** the losses that creep in with manual control—by releasing men who try to control heat by hand—by preventing spoiled or substandard output—by using the necessary amount of heat *only.*



The Powers Regulator No. 15

Entirely self-contained. Thermostat bulb may be placed wherever needed, and connected with steam valve by flexible tube of any required length.

Especially adapted to the control of air or gas temperatures—in lumber kilns, textile and leather drying processes, grain and vegetable dryers, etc.

Other Powers Regulators for other specific industrial operations where heat is a factor.

We shall be glad to give you the benefit of our more than thirty years' experience in temperature regulation; and if you will tell us where you would like to try out a Powers Regulator, we will send the right one for thirty days' trial. If you don't find it satisfactory, send it back.

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Specialists in Automatic Heat Control

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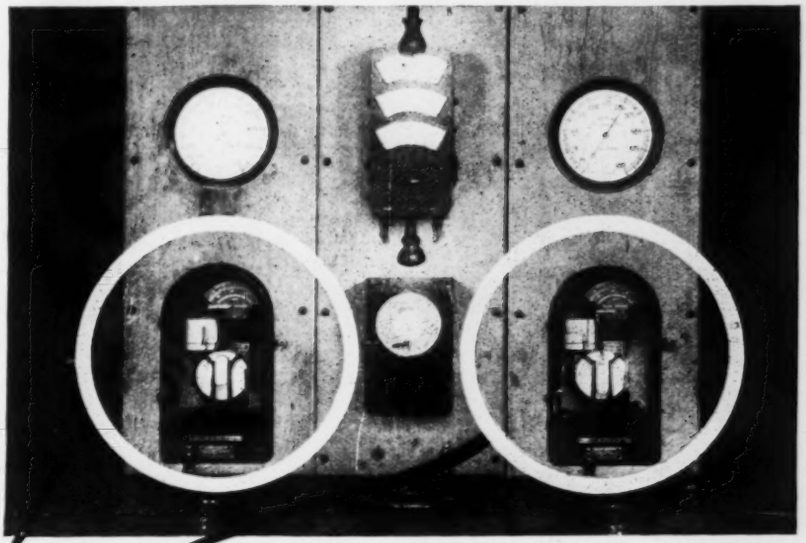
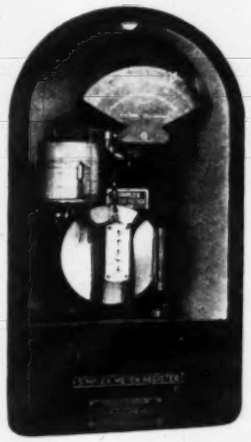
Calgary, Alta. Halifax, N. S. Montreal, Que.
Vancouver, B. C. Winnipeg, Man.

(1079E) See Our Data in 1922 A.S.M.E. Condensed Catalogues of Mechanical Equipment

34 Simplex Feed Water Meters

Are Recording the Flow of Boiler Feed





Typical Boiler Room Instrument Board, Colfax Station, Showing Two Simplex Boiler Feed Water Meters

Simplex Type G Boiler Feed Water Meter

The record is drawn on a rectangular chart that gives the flow in pounds per hour at 200° F. At the same time the flow is both indicated on a dial graduated in pounds per hour and in boiler horsepower, and totalized in pounds on an integrating register.

The pounds of water delivered to the boiler are continuously indicated, recorded, and totalized, *and thus the efficiency of the plant is given at all times. Every day's run becomes an evaporation test that shows the overall average rather than chance results of a single boiler test.*

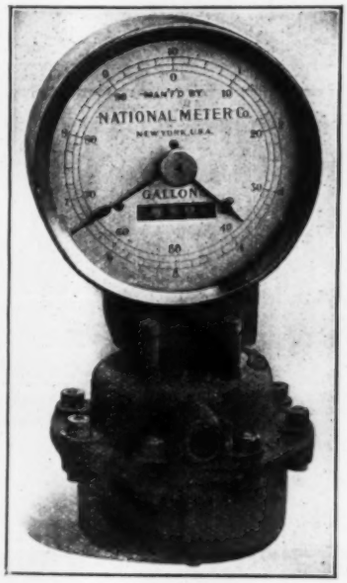
A total of 34 Simplex Feed Water Meters are installed—two for each boiler. Two Simplex Condensate Meters and two Simplex Feed Make-up Meters on evaporator lines are also installed.

Simplex Meters insure accurate measurements for all rates of flow and put a particular emphasis upon high average plant performance—hence their importance cannot be over-emphasized.

Simplex Valve & Meter Company

Manufacturers of Hot and Cold Water Meters, Rate of Flow Controllers, Automatic Air Valves, Regulating Valves and Hydraulic Apparatus of Special Design.

5727 Race Street **Philadelphia, Pa.**



FUEL OIL ACCURATELY MEASURED

BY A METER THAT IS PROPERLY DESIGNED, PROPERLY BUILT, PROPERLY ADJUSTED, AND THAT *RETAINS* ITS ACCURACY

The EMPIRE

The Empire meter is a positive displacement device, operated by an easy-moving, practically frictionless oscillating piston. It has an unmatched record, covering nearly forty years, for closeness of registration and durability.

MADE IN ALL SIZES, 5/8" TO 6". SEND FOR CIRCULAR NO. 109

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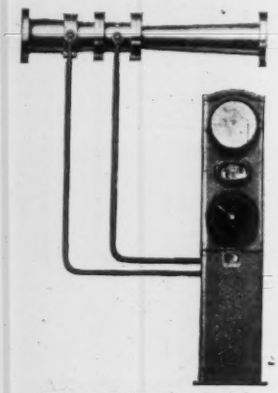
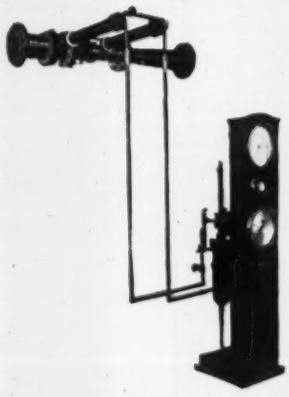
BUILDERS VENTURI IRON FOUNDRY

THE VENTURI METER WILL TELL YOU



Venturi Boiler Feed Water Meter

1. How many pounds of water are evaporated for each pound of fuel burned.
2. Which boilers are efficient and which need cleaning or repairs.
3. When a boiler can be cut out or another boiler should be put in service.
4. Whether or not the water tender is doing his work well.
5. Which kind and grade of fuel is most economical for your boiler plant to use.
6. How much steam is used in the engine room.
7. How much steam is used for manufacturing processes.
8. How much steam is supplied for heating.
9. How much condensation is returned to the boilers.
10. How much circulating water is used by the condensers.



Venturi Steam Meter

Is not knowledge of these things vital for efficient power plant operation? The Venturi Meter is giving this information every day in thousands of power plants throughout the United States and Canada. Our accumulated experience in this field is at your disposal.

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Shall we send you further details?

BUILDERS IRON FOUNDRY, PROVIDENCE, R. I.

NEW YORK PORTLAND, ORE. SAN FRANCISCO PHILADELPHIA LOS ANGELES
DALLAS KANSAS CITY PITTSBURGH TORONTO, CAN. CHICAGO OTTAWA, CAN.

"Emco" Meters and Regulators

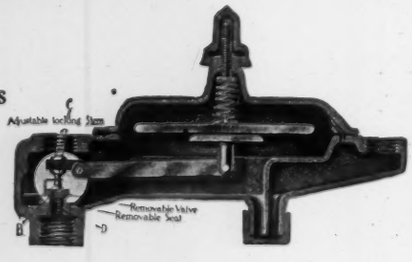
For Artificial and Natural Gas

Meters for Low and High Pressures

Proportional Meters

Provers, Gauges and Burners

Regulators of all kinds



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Company Member of American Gas Association

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TREASURY SAVINGS CERTIFICATES

for *investment.*

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—indicating, integrating and recording steam flow. A guide to correct firing, a vital element of combustion efficiency and a record of steam consumption of units and departments. *Steam Flow —CO_2 Recorder (Model SFC)*—the only instrument giving a graphic record of per cent of CO_2 and amount of steam flow on one chart. Valuable comparisons can be made. The CO_2 Recorder is also furnished without steam flow recorder.

Republic Flow Meters Co.

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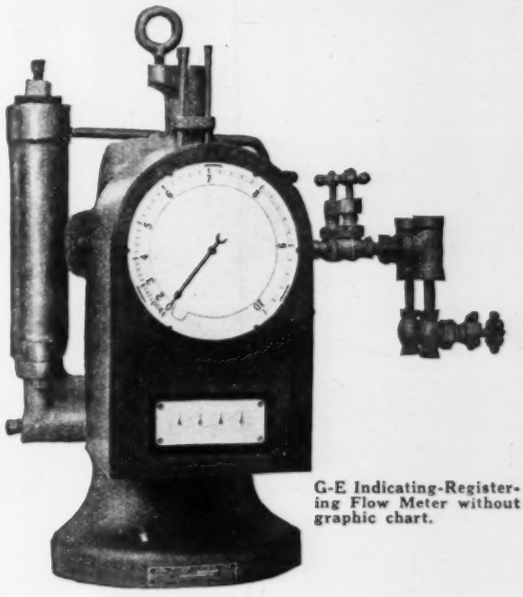
New York, Philadelphia, Boston, Pittsburgh, Detroit, Birmingham, Kansas City, Denver, Milwaukee, Seattle, Portland, Ore., San Francisco.

Los Angeles, Dallas, Republic Flow Meters Co., of Canada, Ltd., Toronto, Ontario, Burton Dunglinson, 9 Oxford St., London, England.

G-E REGISTERING FLOW METERS

G-E Indicating-Recording-Registering Flow Meter with recording temperature and pressure gauges.



G-E Indicating-Registering Flow Meter without graphic chart.

G-E Indicating-Recording-Registering Flow Meter with Recording Pressure Gauge.

G-E Indicating-Recording-Registering Flow Meter with Recording Temperature Gauge.

These newly designed G-E Flow Meters can be furnished for four different combinations of reading:

—flow;
—flow and temperature;
—flow and pressure;
—flow, temperature and pressure.

They can also be supplied without the graphic chart, for indicating the rate of flow and registering the total flow.

General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities

34C-56

COAL TALLY
CO_2 Recorders in the Chief Engineers Office keeping him posted on furnace conditions for each individual boiler

UEHLING CO_2 Recording Equipment

Measures Fuel Wasted Up the Chimney

Uehling CO_2 Equipment is simple, accurate, easy to operate and has no moving parts. The gas is kept clean from the start by **"Pyro-porus"** filtration, an exclusive Uehling feature.

Absorption of CO_2 is by a dry cartridge, thus eliminating messy chemical solutions.

The record is continuous (not intermittent). The auxiliary Indicator for the boiler front tells the fireman when he is wasting fuel.

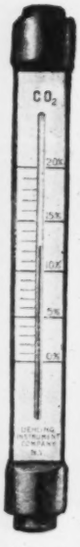
Above are some of the reasons why the Corn Products Refining Co. have ordered 54 Uehling CO_2 recorders, the Detroit Edison Co. have ordered 61, the Ford Motor Co. 19, the Solvay Process Co. 43, the Southern Calif. Edison Co. 60, Standard Oil Companies 104, U. S. Rubber Co. 25, S. D. Warren Paper Co. 14 and Whittaker Glessner Co. 25.

The following bulletins are yours for the asking.

Magnitude of the Power Plant's Chimney Loss

Relation Between CO_2 and Money Wasted Up the Chimney

Catalog 112 describing Uehling equipment.



CO_2 indicator at boiler front to guide the fireman

Uehling Instrument Co.
Combustion Engineers
28 Vesper St., Paterson, N. J.

See Our Exhibit at the New York Power Show

EXECUTIVES COME TO BRISTOL BECAUSE BRISTOL MAKES THE PRECISE INSTRUMENT THEY NEED

Plain Facts Made Plain

It Pays to Know

Ignorance is never bliss in business. So whether your field is one of pressure, temperature or electricity, remember that

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Instruments

are standard the world over. The simplicity and careful construction of the pressure elements insure long operation and sustained accuracy.

Ask for Bulletin C-1095

See our data in 1922 A.S.M.E. Condensed Catalogues.

Why not ask a Bristol User?

THE BRISTOL CO., Waterbury, Conn.

Branch Offices:
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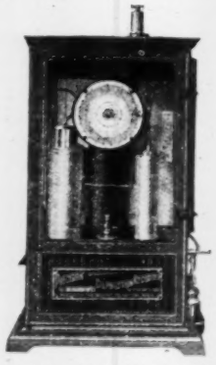
Precision CO_2 Recorders



Precision CO_2 Recorder

A Precision CO_2 Recorder on your boiler will mean reduced coal consumption, save you money and assist the nation in the crisis that confronts us. Coal will be hard to obtain all winter. You can, however, protect yourself and keep your plant in operation.

Send for Catalogue

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PRECISION INSTRUMENT CO.

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TEMPERATURE INSTRUMENTS
INDICATING-RECORDING-CONTROLLING

By means of consistent accuracy and ability to stand the unusual strains *Tycos* Temperature Instruments have become the standard in their field. Mechanical Engineers recognize this and advise their installation whenever temperature problems arise.

Reference catalogs for Engineers will be sent without obligation to all those who state their firm connection.

Taylor Instrument Companies
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There's a Tycos or Taylor Temperature Instrument for Every Purpose

Tycos

Model 432 Single Phase Portable A.C. Weston, Jr., Wattmeter

of Weston Model 310 Precision Instrument

Model 432 Wattmeter of the new Weston, Jr., group is predestined to occupy as distinctive and important a position—as a small instrument—as that always held by its larger, more expensive and world-famous brother, Weston Model 310 Wattmeter.

Model 310 has always been indispensable for both work of utmost precision and as a secondary standard for checking other instruments. Model 432 Wattmeter and Models 433 Voltmeter and Ammeter, on account of their lightness, compactness and typical Weston dependability, will be just as indispensable for making all general commercial measurements where more accurate and costly instruments are not required.

The New

WESTON, JR.,

Portable A. C. Group, including Wattmeters, Voltmeters, Ammeters and Milliammeters.

Model 432 Wattmeters are made with double voltage and single current ranges. Shielded against external magnetic fields. Negligible temperature errors. Ranges up to 50 amperes and 300 and 150 volts self contained. Model 433 Voltmeters have either single or double range. Ammeters—a single range. Accurate within ½%. Wattmeters or Ammeters when used with Weston Multi-Range Current Transformer Model 461 permit measurements up to 800 amperes. Bakelite cases. Strong carrying handles. Wattmeter costs $50 and up—Voltmeter, $30 and up—Ammeter, $28 and up.

This series is so unique, practical and necessary that you should know all about it at once. Bulletin 2006 describes and illustrates the instruments fully. Write for it TO-DAY.

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Branch Offices in All Principal Cities

The Veeder Mfg. Co.

MANUFACTURERS OF
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COUNTERS, SPEED COUNTERS FINE DIE CASTINGS,

Hartford, Connecticut

ENGINE INDICATOR WITH POWER COUNTER

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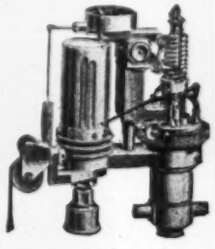

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Gives You Instantaneously

The M.E.P.

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PLANIMETER

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ROUND TRUE TO SIZE

STRAIGHT HIGHLY POLISHED

SHAFTS

OF EXTREME PRECISION

Ground Shafts cost more than ordinary shafts on the cars but—Ground Shafts cost less than ordinary shafts when assembled in the machine—Why?

Let us tell you why—as well as about Cumberland Ground Shafts.

CUMBERLAND STEEL CO.
CUMBERLAND, MD.

~~MEDART~~

OCT. 16TH

ON October 16th we distributed our new condensed catalogue No. 43. You should find a copy in your office files. But, if not, make request for your copy today.

This catalog contains illustrations, construction details, line drawings, dimensions and price lists on Medart Line Shafting Equipment. It will be useful to superintendents, purchasing agents, owners, managers and master mechanics of power plants, as well as to designers and draftsmen who plan power transmission installations; likewise to dealers and salesmen of transmitting machinery.

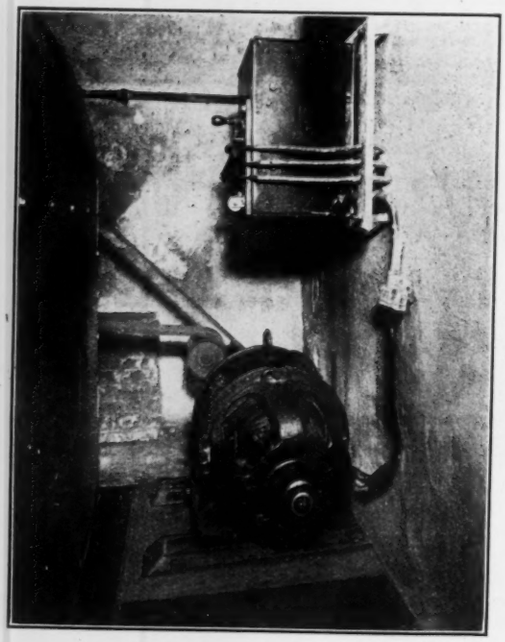
We will cheerfully give you engineering advice, as well as costs, on line shafting equipment and kindred installations.

More extended information on various Medart products is contained on page 246 of the 1922 A.S.M.E. Condensed Catalogues

THE MEDART COMPANY
(Formerly Medart Patent Pulley Co.)
General Offices and Works: St. Louis, U. S. A.
Office and Warehouse: Cincinnati Offices: Chicago and Philadelphia

~~MEDART~~ means EVERYTHING in LINE SHAFTING EQUIPMENT

THE LENIX DRIVE



The ability of the LENIX Drive to transmit full load under conditions where an ordinary open belt drive could not operate efficiently is demonstrated in the installation illustrated.

This 10 H.P. Motor driving a fan is installed in a corner back of the fan casing. The floor space is extremely limited and the tight of the belt on top, but the load is transmitted without the high initial tension that would be required with an ordinary open belt drive.

Belt slippage is eliminated by the great arc of contact given by the Lenix.

Booklet

"Saving Slippage and Space"

contains interesting data on belt drives. Ask for a copy.

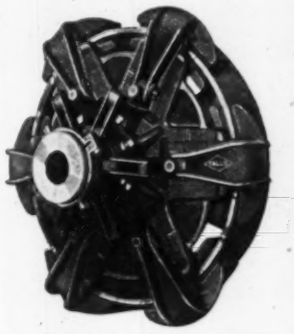
A description of the Lenix and other products of this company will be found in the 1922 A.S.M.E. Condensed Catalogues of Mechanical Equipment.

F. L. SMIDTH & CO.,
Engineers
50 Church St., New York, N. Y.

Power Transmission Machinery

Belt or Rope Distribution

Complete Engineers Catalogue on Request



Six-Arm Friction Clutch Coupling

FALLS CLUTCH & MACHINERY COMPANY

Engineers, Founders and Machinists

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BRANCHES

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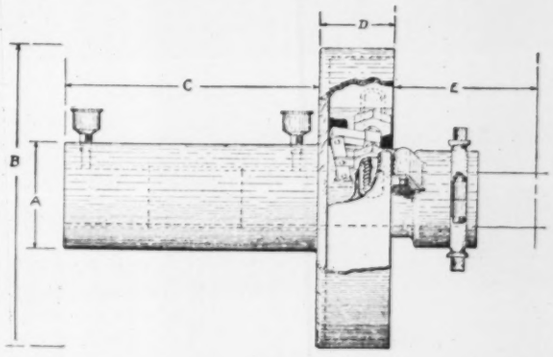
3



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Brown Inner Ring Expanding Line Shaft Clutches have demonstrated their superiority for twenty years, being unequalled for durability, ease of installation, and convenience of adjustment.

Ratings are by actual brake horse-power capacity; and over-all proportions as indicated above.

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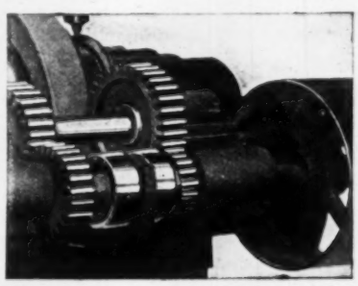
The Brown Clutch Co.

Manufacturers of
Friction Clutches and Friction Hoists

SANDUSKY, OHIO

THE JOHNSON FRICTION CLUTCH

in a standard size just dropped in between these spur gears on the William's pipe threading machine.



A Johnson Clutch will solve your machine control problems.

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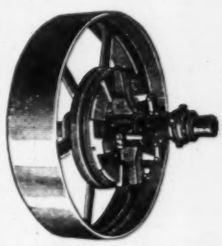
THE CARLYLE JOHNSON MACHINE CO. MANCHESTER CONN.

CLUTCH



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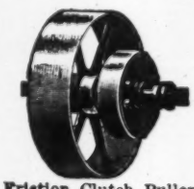
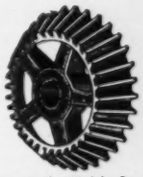


Friction Clutch Pulleys and Couplings

POWER TRANSMISSION MACHINERY

DESIGNED, FURNISHED AND ERECTED



Gears of all kinds and sizes

SPECIAL MACHINERY

IRON CASTINGS

Works: ELIZABETHPORT
NEW JERSEY

Sales Room: 79 BARCLAY ST.
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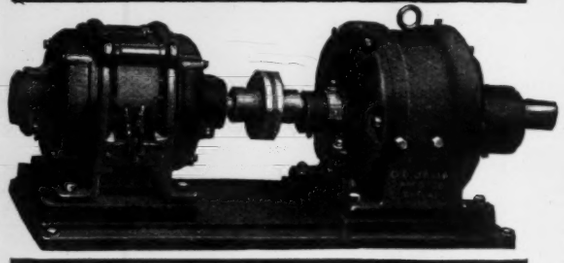
James Speed-Reducing Transmissions



James Transmissions eliminate complicated open Gearing, Shafting, Belts and Pulleys not to mention the great loss thru friction. Send for Bulletin descriptive of our Speed Reducing Transmissions. Manufacturers of cut Gears of every description.

D. O. James Mfg. Co.
1114 W. Monroe St., Chicago, Ill.

Provide Operating Economy

See our data on page 232 in 1922 A.S.M.E. Condensed Catalogues

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Title	Author	Order No.	Prices To Members	To Non-Members
Ball-Bearing Lineshaft Hangers	Henry Hess	1286	.25	.35
Plastic Indentation of Steel Balls under pressure	C. A. Briggs, W. C. Chaplin and H. C. Heil	1643	.25	.40
A Self-Adjusting Spring Thrust Bearing	H. G. Reist	1646	.25	.40
Slow-Speed and Other Tests of Ringsbury Thrust Bearings	H. A. S. Howarth	1715	.30	.45
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FRANKLIN MACHINE COMPANY

Engineers Founders Machinists
Providence, R. I.

Transmission Machinery, Spun Silk Machinery, Ball Winding Machines, Shoe Lace Tipping Machines, Yarn Dressers, Wool Top and Yarn Baling Presses, Pneumatic Gravity Drop Hammers, Pneumatic Presses, Special Machinery, etc.

HARRIS-CORLISS STEAM ENGINES
Eastern Representative for
Cleveland Worm Gears
and Worm Gear Reduction Units

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Modern and Approved Appliances for the Transmission of Power

SHAFTING HANGERS
COUPLINGS PULLEYS
COLLARS BELT TIGHTENERS
FRICTION CLUTCHES
ROPE DRIVE EQUIPMENTS

T. B. WOOD'S SONS CO.
CHAMBERSBURG, PA.

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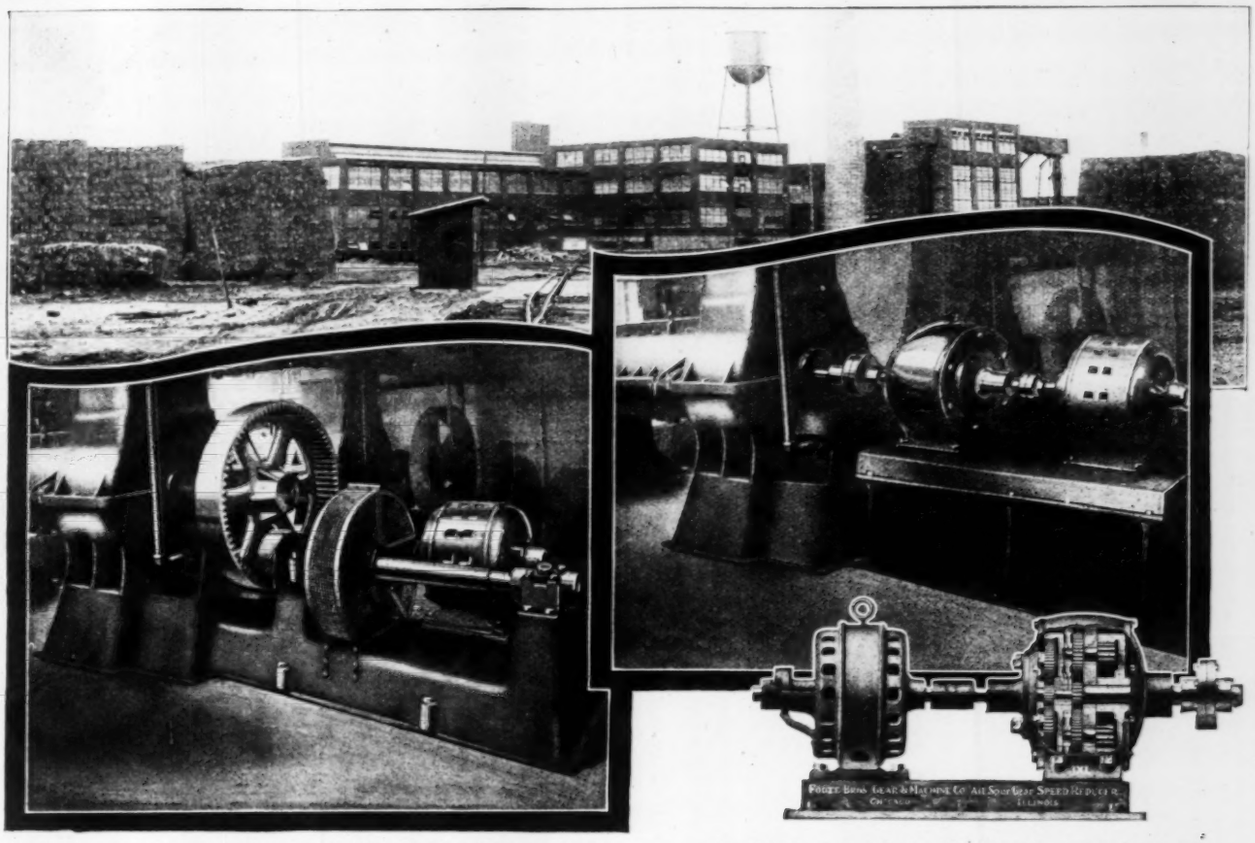

The speed of the motor to run pulp shredder is reduced by means of a pinion gear driving a spur gear from which another pinion gear drives an internal gear. This open equipment is costly to install, causes undue maintenance cost and loss of power.

Showing the same pulp shredder driven by means of motor and Foote Speed Reducers. A high speed motor is used. This makes a compact, efficient, economical drive. This installation requires practically no maintenance.

HOW DO *YOU* DETERMINE THE BEST TYPE OF TRANSMISSION FOR REDUCING THE SPEED OF ELECTRIC MOTORS OPERATING MIXERS, CONVEYORS, AGITATORS, ETC.?

IS YOUR INSTALLATION SPACE LIMITED? *Foote Speed Reducers* are compact. They can be furnished to drive at either end or at top or bottom. They are set close to the motor.

WILL YOUR MEANS OF TRANSMISSION BE SUBJECTED TO DIRT, DUST OR GRIT? Dirt, dust and grit quickly wear out open gears, ropes, chains and belts. All working parts in *Foote Speed Reducers* are enclosed and protected. Their life is long.

ARE YOUR MEN ENDANGERED WORKING NEAR YOUR DRIVES? *Foote Speed Reducers* are fool proof. Workers cannot get their fingers or clothes into moving parts. *Foote Speed Reducers* provide positive safety. They also eliminate fire and explosion hazard.

DO YOU NEED ALL POSSIBLE POWER FROM YOUR MOTORS? *Foote Speed Reducers* are entirely enclosed and all gears run in a bath of oil. End and side thrusts are eliminated and scientific engineering insures the delivery of maximum power.

DO YOU REQUIRE A BIG REDUCTION? *Foote Speed Reducers* are made for motors of any horse power in ratios from 5 to 1 up to 500 to 1.

ARE YOU IN DOUBT AS TO THE PROPER DRIVE TO INSTALL? Our Engineering Department will assist you in solving your speed reduction problems—no obligation to you.

MEMBER OF AGMA

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Mfg's. of Rawhide and Bakelite Pinions and Cut Gears of All Kinds. Send for catalog. Special Machinery made to order. Submit your blueprints.

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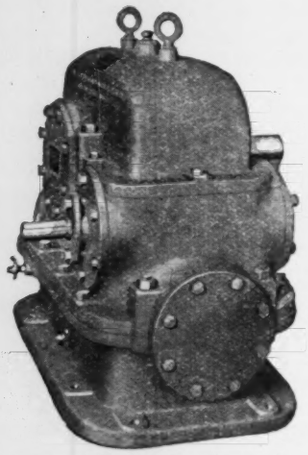
KING & KNIGHT
Underwood Bldg.
San Francisco, Cal.

Cleveland WORM GEAR REDUCTION UNITS



Cleveland Double Reduction Drive

Double Reduction Drives

We are in a position to furnish double reductions with ratios as high as 2000 to 1, such as are now being used in many of the leading steel plants. These are used to operate cooling tables, conveyors, etc.

We have also built a great many double reduction drives for use in other applications. Our double reductions take up considerably less space than any other form of speed reduction and are remarkable for their high efficiency in the transmission of power.

Or, we can furnish single reductions as low as 3⅝ to 1 and as high as 100 to 1.

Where high efficiency, even torque, quietness, compactness and low maintenance cost with *permanent* economy, are desirable you will find nothing to equal Cleveland Worm Gear Reduction Units.

Our latest bulletin gives ample information regarding the construction of our gearing and we will be glad to send it to you. Give us the data concerning any form of speed reduction you may have under consideration and our engineering department will gladly cooperate with yours.

The Cleveland Worm & Gear Co.

America's Worm Gear Specialists

CLEVELAND, OHIO

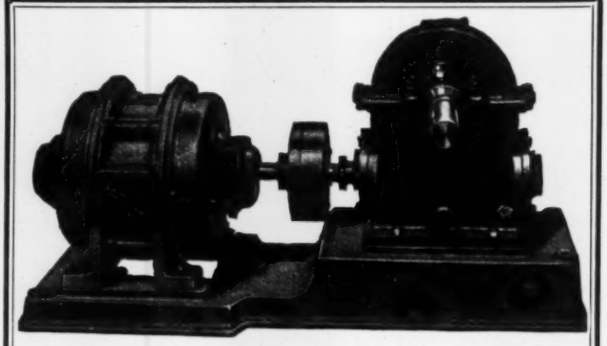
DRAVO-DOYLE CO., Pittsburgh
Cleveland, Indianapolis, Philadelphia

New England Representatives
FRANKLIN MACHINE CO., Providence, R. I.

Pacific Coast Representatives
ALFRED H. COATES CO., San Francisco, Cal.

Rocky Mountain States Representatives
THE VULCAN IRON WORKS CO., Denver, Colo.

See Our Data in 1922 A.S.M.E. Condensed Catalogues of Mechanical Equipment



HINDLEY WORM-GEAR DRIVES

For Power Transmission, the Hindley Worm-Gear Drive will meet your requirements.

Efficient, Safe, and Durable.

Hindley Gear Company
1105 Frankford Ave.
Philadelphia, Pa.

The Engineering Societies Library

ONE of the largest collections of engineering literature in the world is that found in the Engineering Societies Library, 29 West 39th Street, New York.

It comprises 150,000 volumes, including many rare and valuable reference works not readily accessible elsewhere. Over 1,300 technical journals and magazines are regularly received, including practically every important engineering journal in the civil, mechanical, electrical, and mining fields.

The library is open from 9 a.m. to 10 p.m., with trained librarians in constant attendance. Its resources are at the service of the engineering and scientific public.

FAWCUS HERRINGBONE GEARS

QUIET EFFICIENT

ENCLOSED GEAR DRIVES
FLEXIBLE COUPLINGS

SPECIAL MACHINERY

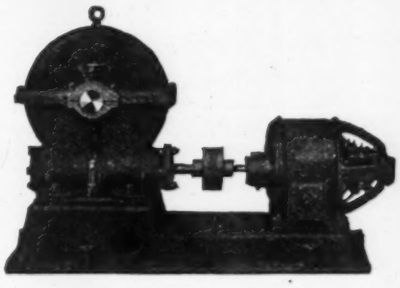
CUT SPUR = CUT BEVEL = CUT WORM = GEARING

FAWCUS MACHINE CO. Pittsburgh, Pa.

See Our Data in 1922 A.S.M.E. Condensed Catalogues of Mechanical Equipment

Jones

Enclosed Worm Gear Drives



Furnished either individually or with Cast-Iron Bases, Flexible Couplings, Motors, etc., assembled and ready for direct connection to shaft of driven unit.

Our enclosed worm gear drives are all equipped with cut tooth worm gears and worms with cut threads. Worms can be single, double, triple or quadruple thread to suit conditions. Metals for worms and gears are any suitable for such purposes.

Send your specifications or ask our recommendation

W. A. Jones Foundry & Machine Company

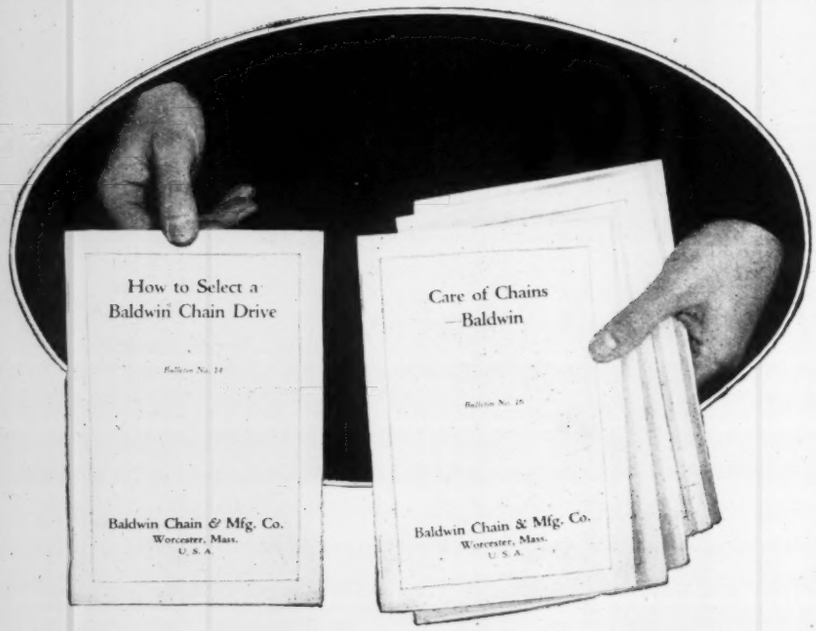
MAIN OFFICE AND WORKS:
4400 West Roosevelt Road, Chicago

BRANCH SALES AND ENGINEERING OFFICES:

26 Murray Street, New York, N. Y.
Union Arcade, Pittsburgh, Pa.
2482 University Ave., St. Paul, Minn.
184 Main Street, Buffalo, N. Y.
1st Wis. Nat'l Bank Bldg., Milwaukee, Wis.

Cast-Iron Pulleys · Friction Clutches · Shaft Hangers · Boxes · Couplings · Cut Gears · Cast Gears
Sprocket Wheels · Rope Sheaves · Flywheels · Enclosed Worm Gear Drives · Spur Gear Speed Reducers

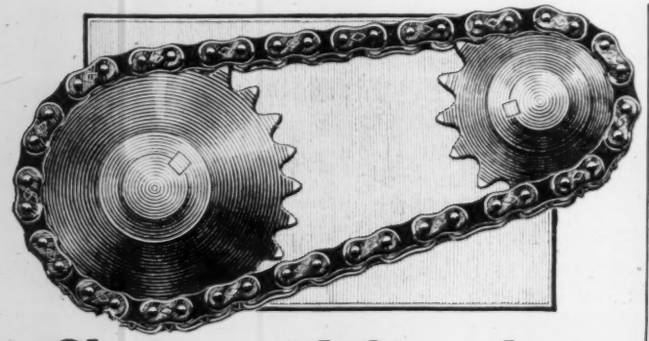
Your OPPORTUNITY to learn the advantages of BALDWIN CHAINS AND SPROCKETS



THESE bulletins have been compiled by Baldwin Engineers to give you complete engineering data on the application and design of chain drives. The Baldwin factory or your nearest Baldwin distributor will be very glad to furnish you with any or all of these bulletins without obligation:

Miscellaneous Application of Chain Drives.
How to Select a Chain Drive.
Care of Chains.
Baldwin Roller Chains.
Baldwin Roller Chain Adaptations—Special Chains.
Baldwin Block Chains.
Data on Baldwin Sprockets for Roller and Block Chains.
Malleable Detachable Chains.
Westlund Friction Clutch.

BALDWIN CHAIN & MANUFACTURING COMPANY
WORCESTER, MASS.
H. V. GREENWOOD, *Western Sales Representative*, PEOPLES GAS BUILDING, CHICAGO, ILL.



Chains and Sprockets

DIAMOND Roller Chains are made in fifty models, ranging from ⅜ to 2 inches in pitch and from ⅛ to 1¼ inches in width. This large line offers you correct chain models for all the needs of machinery drives.

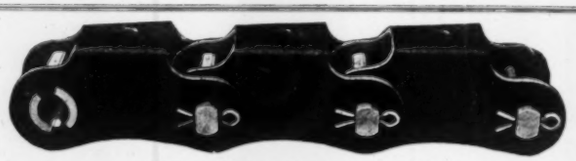
DIAMOND Steel Sprockets can be manufactured to meet your particular drive specifications on reasonably short notice.

For 32 years, this company has specialized on manufacturing roller chain drives and is today the world's largest exclusive maker of steel roller chains and sprockets. Our engineers will gladly assist you in planning DIAMOND Chain Drives for the machinery you manufacture or use.

DIAMOND CHAIN & MFG. CO., Indianapolis, U.S.A.
Makers of High Grade Chains and Sprockets since 1890

DIAMOND Chains and Sprockets

THE PHOSPHOR BRONZE SMELTING CO.
2200 WASHINGTON AVENUE, PHILADELPHIA, PA
PHOSPHOR BRONZE
CASTINGS, INGOTS, RODS, SHEETS, WIRE Etc.
DELTA METAL
IN BARS FOR FORGING AND FINISHED RODS
ORIGINAL AND SOLE MAKERS IN THE U. S.



"The Chain of Double Life"

For standard cast tooth sprockets No. 35 to 6 in. pitch
For cut tooth sprockets 1 in. to 2 in. pitch.

UNION STEEL RIVETLESS CHAINS

The Chains with the Substantial Links and Large Case-Hardened Bearings, which are reversible and renewable.

Roller Chains, Bushing Chains, Attachment Links, Cast Tooth Sprockets, Cut Tooth Sprockets, Elevating and Conveying Machinery

Special Transmission Chains up to 1,000,000 Pounds Ultimate Strength

The Union Chain & Mfg. Co., Sandusky, O.

PROMET GUARANTEE

The order to which this guarantee is attached is subject to the following conditions:

Promet must meet your bearing requirements and must give superior service to any other bearing metal or purchase price in full including freight will be refunded. Your opinion to be final.

The American Crucible Products Co.

THERE are a lot of remarkable facts we might tell you about Promet Bearing Metal.

For instance, it is uniformly giving from six to ten times the service of other bearing metals in every kind of machinery. This one fact is enough to make you interested in Promet.

But we have found that the Promet guarantee reproduced at the top of this page tells the story of Promet better than we can tell it.

We furnish a supply of these gummed stickers, exactly like that shown above, to your purchasing agent, with the request that he stick one of them on every order he sends us.

If we can afford to make this guarantee, can you afford *not* to find out what Promet Bearing Metal will do for you? Just mail the coupon.

THE AMERICAN CRUCIBLE PRODUCTS COMPANY
Elyria, Ohio

Canadian Licensees: Engineering Sales and Service Co., Ltd.
177-179 Duke Street, Montreal, Quebec, Canada

PROMET

THE HEAT-TREATED BEARING METAL

Promet Heat Treated Bronze Bearings and Bushings Are Sold Under the Same Guarantee

The American Crucible Products Company, Elyria, Ohio M2

Please send me facts about Promet Bearing Metal and information regarding its use in.....
(State kind of machinery)

Name.....

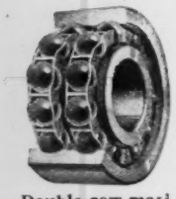
Position.....

Company Name.....

Address.....

City.....State.....

Strom BEARINGS



Double-row maximum type, radial bearing

Double-acting, self-aligning thrust bearing with leveling washers 2100-U Series

Single-acting thrust bearing with flat seats (grooved races) 1100-F Series

Single-acting, self-aligning thrust bearing, leveling washer 1100-U Series

Double-acting thrust bearing, flat seats 2100-F Series

DURABILITY

Durability is the prime requisite of a good ball bearing. It is obtained in Strom bearings by constructing them of material of great strength which is heat-treated to obtain long-wearing quality.

The working elements are correctly balanced in Strom bearings, making each part of equal strength to carry the heaviest loads and endure long service.

It is just such features of construction that make Strom bearings the most logical choice wherever strength, precision, power, and endurance are required.

Single-row, deep-groove Conrad type, radial bearing

Angular contact bearing—combination radial and thrust

Single-row, maximum type, radial bearing

Double-row, deep-groove Conrad type, radial bearing

Made in radial (single and double row), angular contact, and thrust types for any application.

Our engineers will cheerfully assist you in a correct choice of bearings.

"Used Wherever a Shaft Turns"

U.S. Ball Bearing Mfg. Co.

(Conrad Patent Licensee)

4540 Palmer Street

CHICAGO, ILL.

See Our Data in 1922 A.S.M.E. Condensed Catalogues of Mechanical Equipment

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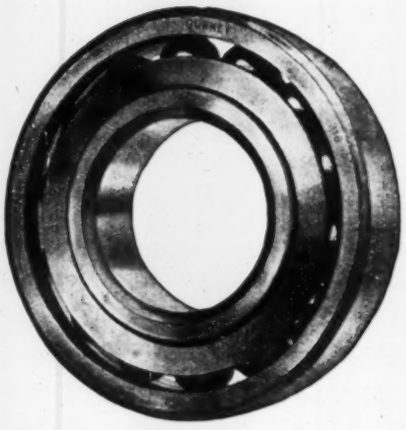


Maximum Safety Factor

COMPARATIVELY for their sizes Gurney Ball Bearings have greater capacity and thus in effect guarantee a maximum factor of safety.

This desirable result is secured by use of the maximum number and size of balls, assembled without use of a filling slot, in raceways whose curvature closely approximates that of the balls. Thus under continuous overload of shock, the theoretical point of contact becomes in fact an area of contact.

Let Gurney engineers assist in simplifying and economizing on your bearing problems.

Gurney Ball Bearing Co.

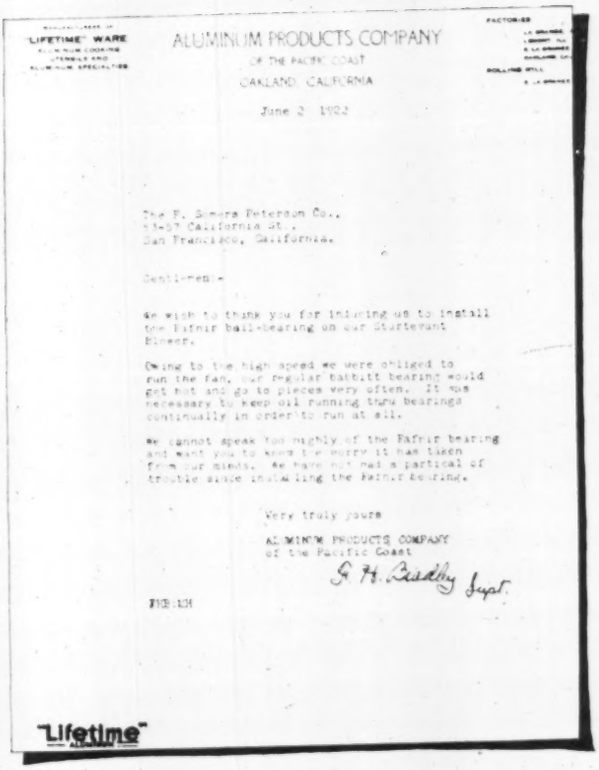
Conrad Patent Licensee

Jamestown, N. Y.

18103

GURNEY BALL BEARINGS

FAFNIR



"LIFETIME" WARE
ALUMINUM COOKING UTENSILS AND ALUMINUM SPECIALTIES

ALUMINUM PRODUCTS COMPANY
OF THE PACIFIC COAST
OAKLAND, CALIFORNIA

FACTORIES

June 2 1922

The F. Somers Peterson Co.,
53-57 California St.,
San Francisco, California.

Gentlemen:-

We wish to thank you for inducing us to install the Fafnir ball-bearing on our Sturtevant Blower.

Owing to the high speed we were obliged to run the fan, our regular babbitt bearing would get hot and go to pieces very often. It was necessary to keep oil running thru bearings continually in order to run at all.

We cannot speak too highly of the Fafnir bearing and want you to know the worry it has taken from our minds. We have not had a partical of trouble since installing the Fafnir bearing.

Very truly yours

ALUMINUM PRODUCTS COMPANY
of the Pacific Coast

G. H. Bradley Supt.

FHB:KH

"Lifetime"

For Reliability and Efficiency Install Fafnir Double Ball Bearing Blower And Fan Boxes

Fafnir Double Ball Bearing Blower and Fan Boxes will pay for themselves many times over in power, oil and labor saved, and above all, in *reliability.*

These boxes involve unit construction and fit all standard types of blowers and fans.

Read what *Fafnir Blower and Fan Boxes* have done for the Aluminum Products Co.—They will do just as much for you.

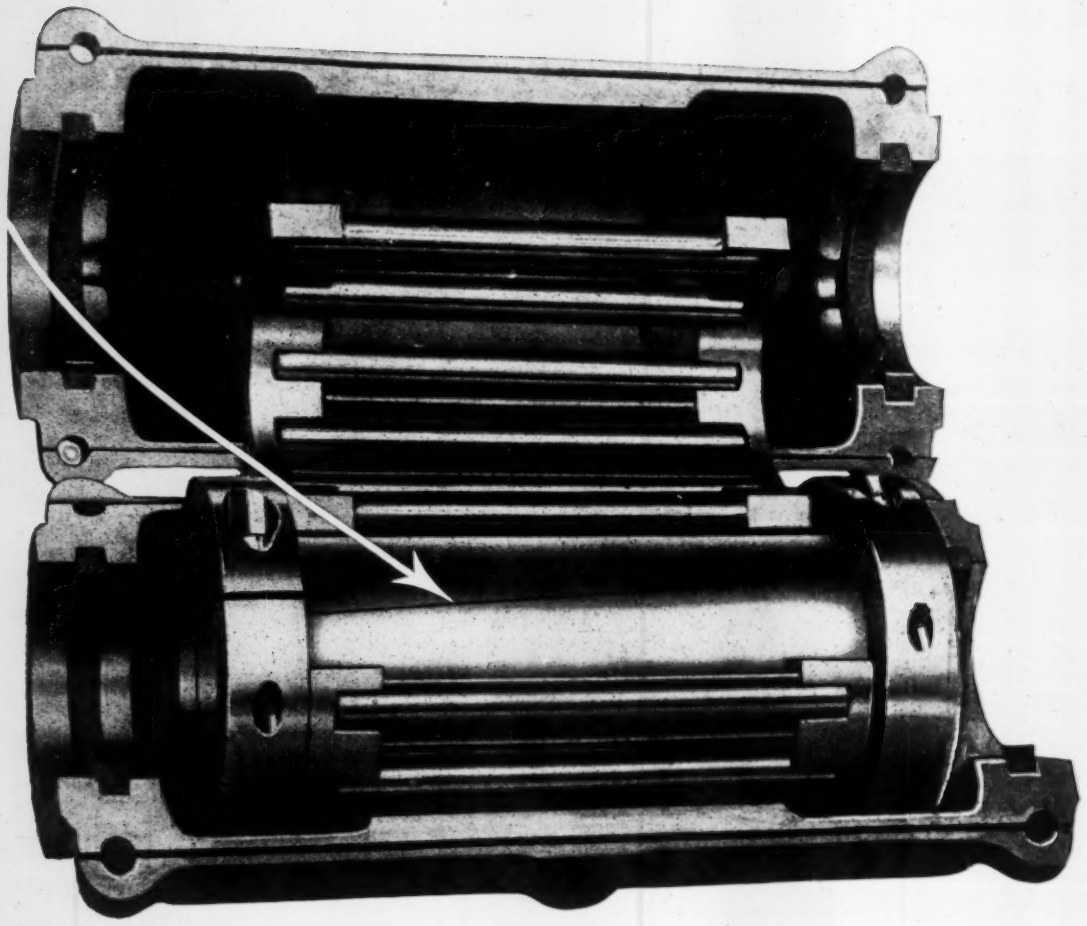
The Red Dragon Line

THE FAFNIR BEARING COMPANY

Conrad Patent Licensee
New Britain, Conn.

DETROIT Office: 752 David Whitney Bldg.
CLEVELAND Office: 1016-1017 Swetland Bldg.
NEWARK Office: 271 Central Avenue
CHICAGO Office: 1002 Ellsworth Bldg.
NEW YORK Office: 5 Columbus Circle

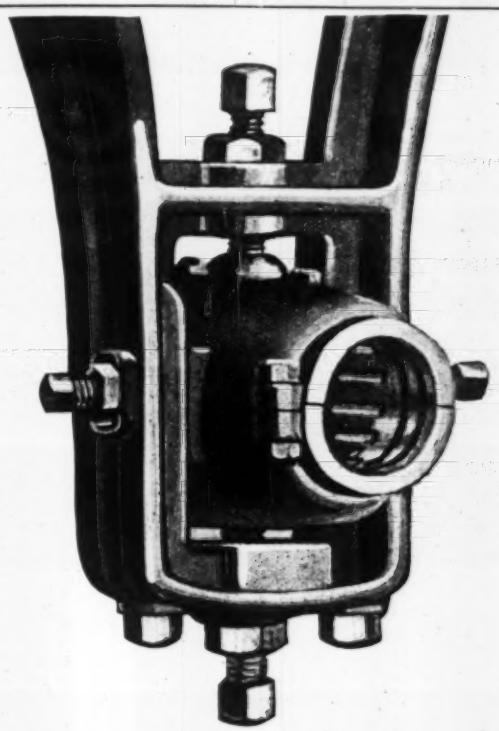
This split-steel sleeve which covers the places worn uneven in the shaft by the former bearings is a patented feature of the Sells Bearing.



In covering the hills and gullies, this sleeve also prevents future wear on the shaft, which, as you know, is softer steel.

This split-steel sleeve advantage alone (and there are seven others*) has influenced thousands of concerns to adopt Sells Roller Bearings.

Sells



* *Put Sells Roller Bearings right in your present hanger frames, post hangers or pillow blocks. No extra cost—no loss of production. Rollers are self-contained and do not engage each other; no binding in cage rings or skewing effect.*

Note the individual collars which hold the sleeve fast to the shaft.

In Sells Roller Bearings, you find the good points claimed for all other bearings with the defects of none.

A Few Installations

Millers Milling Company
Aunt Jemima Mills Co.
French, Shriner & Urner
United Shoe Machinery Co.
Gillette Safety Razor Co.
American Agricultural Chemical Co. (25 plants)
Newberry Cotton Mills
Babcock & Wilcox Mfg. Co.
Borden Condensed Milk Co.
Dodge Brothers
American Car & Foundry Co.
Smaltz-Goodwin Co.
Thornhill Wagon Co.
The American Fork & Hoe Company
Macwhyte Company

Wouldn't the fact that these nationally-known concerns have installed *Sells* Roller Bearings cause you to look into them—talk to our engineers?

At least you can ask us to send some recently written letters from those who have used Sells Roller Bearings for several years. And you will find that practically every one of these letters in praising the performance of the Sells Bearing and its lack of upkeep cost, also mentions savings in coal or power from 10 to 40 per cent.

But let's get things started now—*today*, for the longer you put it off, the greater hole is friction digging into your coal pile, or the more kilowatt consumption is being piled on your power bill.

Royersford Foundry & Machine Co.
60 N. 5th Street, Philadelphia, Pa.

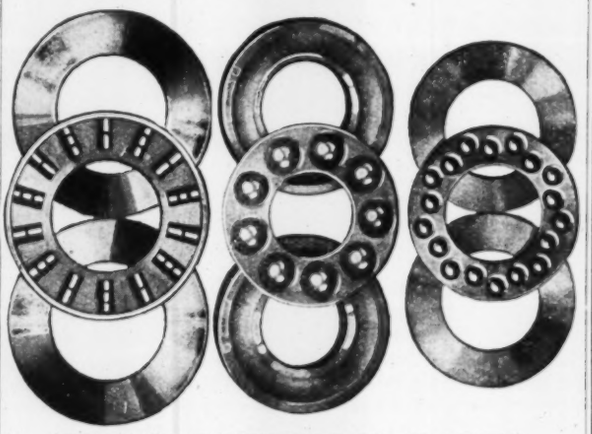
Roller BEARINGS

"NORMA"
PRECISION
BALL BEARINGS

If "repeat orders" fail to come to the builder of a "NORMA" equipped machine, he may be resonably sure that bearing troubles are not to blame. Our engineers like to help make good machines better. May one call?

THE NORMA COMPANY OF AMERICA
Anable Avenue
Long Island City New York
BALL, ROLLER AND THRUST BEARINGS

THRUST
BEARINGS



STANDARD DIMENSIONS OR TO ORDER
One or—one thousand

See our data on page 265 in the 1922 A.S.M.E. Condensed Catalogues of Mechanical Equipment.

THE GWILLIAM COMPANY
253 West 58th St., New York, N. Y.
2218 Chestnut St., Philadelphia, Pa. 23 Flatbush Ave., Brooklyn, N. Y. 418 Melwood Ave., Pittsburgh, Pa.

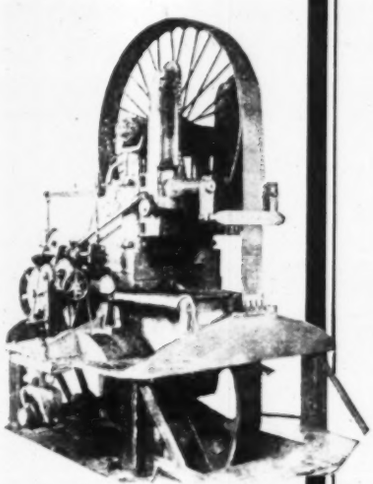
A Few Important A.S.M.E. Standards

No.	Price Mem.	Non-Mem.
1142—Standard Proportions for Machine Screws	.25	.40
1398—Standard Threads for Hose Couplings	.25	.35
1399—Standardization of Pipe Thread Gages	.25	.35
1733—Manual on American Standard Pipe Threads	.35	.50
1779—Screw Thread Tolerance Report	.25	.35
1654—Report of Committee on Standardization of Flanges and Pipe Fittings	.25	.35
1469—Boiler Code	.75	1.00
1778—Rules for construction of Locomotive Boilers	.25	.35
Miniature Boiler Code	.25	.35
1526—Power Test Code	1.00	2.00
1305—Identification of Power House Piping	.25	.35
1572—Code of Safety Standards for Cranes	.25	.35
1597—Code of Safety Standards for Industrial Ladders	.25	.35
1598—Code of Safety Standards for Power Transmission Machinery	.25	.35
1631—Code of Safety Standards for Woodworking Machine Guards	.25	.35
Safety Code for Elevators	.65	.65
X101—Report of Committee on Standards for Graphic Presentations	.25	.35
1510—Standardization of Safety Principles	.35	.40

No order filled for less than 50 cents

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
29 WEST 39th STREET, NEW YORK

Timken Tapered Roller Bearings in both the top and bottom wheels of this Wheland Band Mill are cutting down power consumption to one-half of that formerly used.



Saving 75 H P With Timkens

As a result of using Timken Tapered Roller Bearings in the new Eight Foot Wheland Band Mill, made by the Wheland Company of Chattanooga, Tennessee, the mill requires only one-half as much power as was formerly used.

"A saving of 75 H P is made in the driving of the mill alone," says Mr. G. W. Wheland, President of the Company. "A proportionate saving is effected throughout the transmission equipment, for the mill now operates to capacity with a sixteen-inch belt, whereas a twenty-inch belt was previously necessary."

Such records of power conservation by the use of Timken Tapered Roller Bearings are not at all uncommon or phenomenal. Through their ability to carry radial loads, thrust loads, and resultant loads, they are reducing friction to an absolute minimum in nearly every type of industrial machinery.

And finally, by means of their tapered construction, their durability is indefinitely prolonged through the unassailable engineering principle of *adjustment* instead of *replacement*. When the wear which *must* follow any motion does occur (no sooner with Timkens than any other bearing), a simple, quick, easy adjustment, and Timken Tapered Roller Bearings function as when new.

The Timken Roller Bearing Co
CANTON, OHIO

—*Will Also Save Power and Money in*—

Blowers and Compressors
Clay Working Machinery
Cranes
Dairy Equipment
Electric Motors
Electrical Machinery
Elevator Drives
Farm Lighting Units
Gasoline Rail Cars
Gas Motors
Gas Producers
Grain Milling Machinery
Grinders
Hoisting and Conveying Machinery
Industrial Tractors and Trucks
Laundry Machinery
Lawn Mowers
Machine Tools
Mine Cars
Mining Machinery
Oil Well Machinery
Paper Making Machinery
Power Transmission Machinery
Printing Presses
Pumps
Railway Equipment
Refrigerating Machinery
Road Making Machinery Wheels
Separating Machinery
Shoe Machinery
Steel Mill and Foundry Equipment
Stokers
Street Railway Cars
Street Sweepers
Textile Machinery
Tire Making Machinery
Ventilating Machinery
Wood Working Machinery

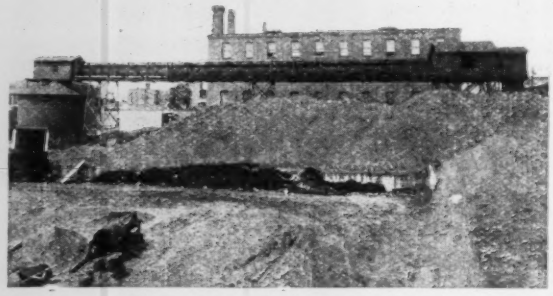
—*and Wherever There Is Friction*

© 1922, T R B Co, Canton, Ohio

TIMKEN
Tapered
ROLLER BEARINGS

BUILT STRONGER LASTS LONGER

G-W MATERIAL HANDLING EQUIPMENT



A "Safety-First" Coal Supply

Be on the safe side when a coal shortage comes. Why worry where your next load of coal is coming from when a G-W Ground Storage Plant can be installed at such a conservative cost?

The ample storage facilities of a G-W Ground Storage Plant enable you to buy coal when the market is most favorable and to have it on hand when your competitors are paying a fancy price and still not getting deliveries.

Send for a G-W representative to show you how a "Safety-First" coal supply can be assured in your plant.

See Our Data in 1922 A.S.M.E Condensed Catalogues of Mechanical Equipment, 2120-R

Gifford-Wood Co. WORKS HUDSON N.Y.
NEW YORK-CHICAGO BOSTON-BUFFALO

BLOW 4,000 Ft.

SHAVINGS SAWDUST OR PULP CHIPS

With a positive pneumatic conveyor.

We Install and Guarantee Operation.

THE ALLINGTON & CURTIS MFG. CO.
Incorporated 1888
Factories & Offices: Saginaw, Mich.
321 Rutherford Avenue, Boston, Mass.
Offices: 565 Washington Blvd., Chicago, Ill.
333 St. Paul Pl., Baltimore, Md.; 45 West 18th St., New York, N. Y.

See Our Data in 1922 A.S.M.E Condensed Catalogues of Mechanical Equipment

ROEBLING

WIRE ROPE SLINGS
for
Industrial Plants

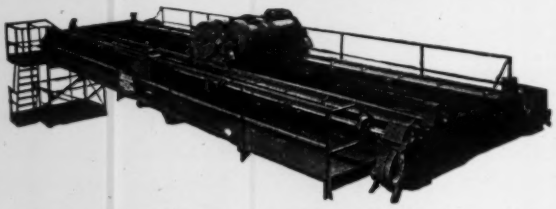
Strong, Durable Equalizing Thimbles.

High Safety Factor
Our Blue Center Steel Used

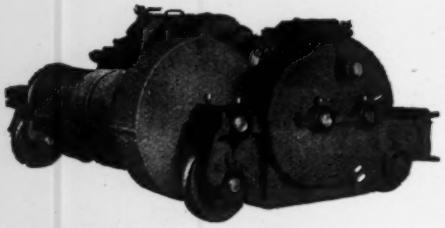
John A. Roebling's Sons Co., Trenton, N. J.

See Our Data in 1922 A.S.M.E Condensed Catalogues of Mechanical Equipment

NORTHERN CRANES



Our type E Cranes for either standard or mill service will interest those who buy and use cranes. Enclosed non-overhung gearing—simple substantial design—Good workmanship—The "Repeat Order" Crane.



(Also Electric Hoists)

NORTHERN ENGINEERING WORKS
DETROIT MICHIGAN ~ U.S.A.

SPECIALIZED CONSULTING SERVICE

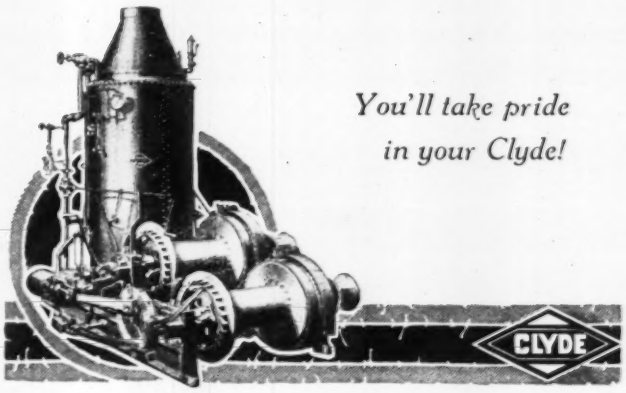
in ALL BRANCHES of the ENGINEERING FIELD

The cards of Consulting Engineers appearing on pages 108, 109 110, 111, 112 and 113 serve as an index to professional service in the mechanical field. Specialized service may be obtained through this section on such subjects as

Accounting
Appraising
Combustion
Construction
Copyrights
Cost Systems
Designing
Foundries
Heating and Ventilating
Hydraulic Work
Industrial Plants
Inspection
Machinery Designing
Management
Manufacturing Methods
Organization
Patent Law
Plant Constructio
Power Plants
Power Transmission
Production
Refrigeration
Research
Special Machinery
Taxes
Testing
Tool Designing
Trade Marks
Water Purification
Water Supply

Clyde's Greatest Asset—

Hundreds of satisfied customers who always specify Clyde Equipment on repeat orders.



You'll take pride in your Clyde!

CLYDE

Clyde Iron Works Sales Company
DULUTH, MINN., U. S. A.
Sole Distributors for Clyde Iron Works
NEW YORK CHICAGO NEW ORLEANS JACKSONVILLE SEATTLE PORTLAND CINCINNATI

LIDGERWOOD HOISTS
STEAM - ELECTRIC - GASOLENE

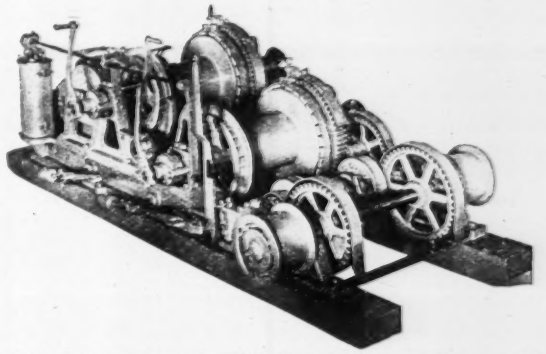


Illustration shows Double Drum Electric Hoist, with boom swinging clear for derrick work

We have types to meet every kind of hoisting service

STRENGTH - SPEED - ECONOMY
are features of all Lidgerwood
HOISTS - DERRICKS - CABLEWAYS
REQUESTS FOR CATALOGS INVITED

LIDGERWOOD MFG. CO.
96 LIBERTY STREET NEW YORK
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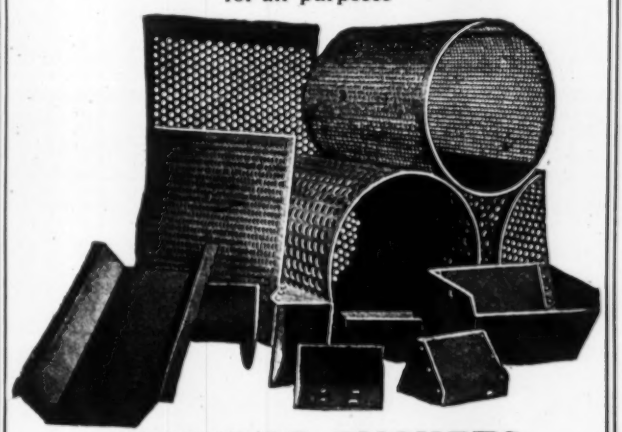

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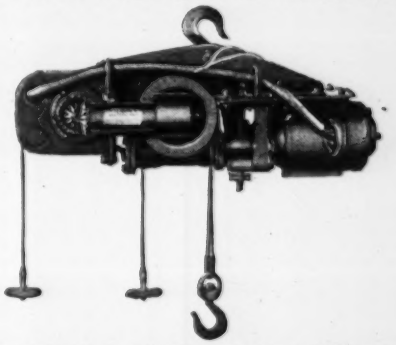

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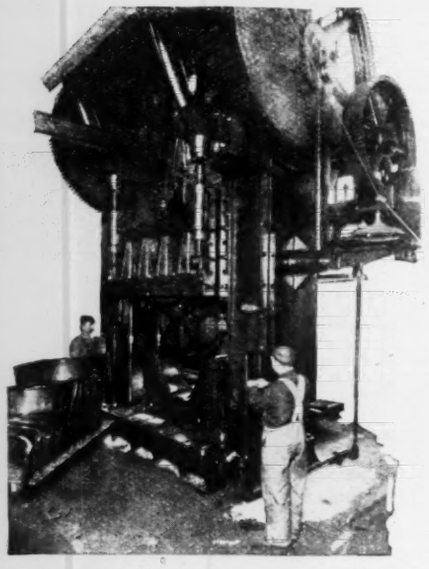

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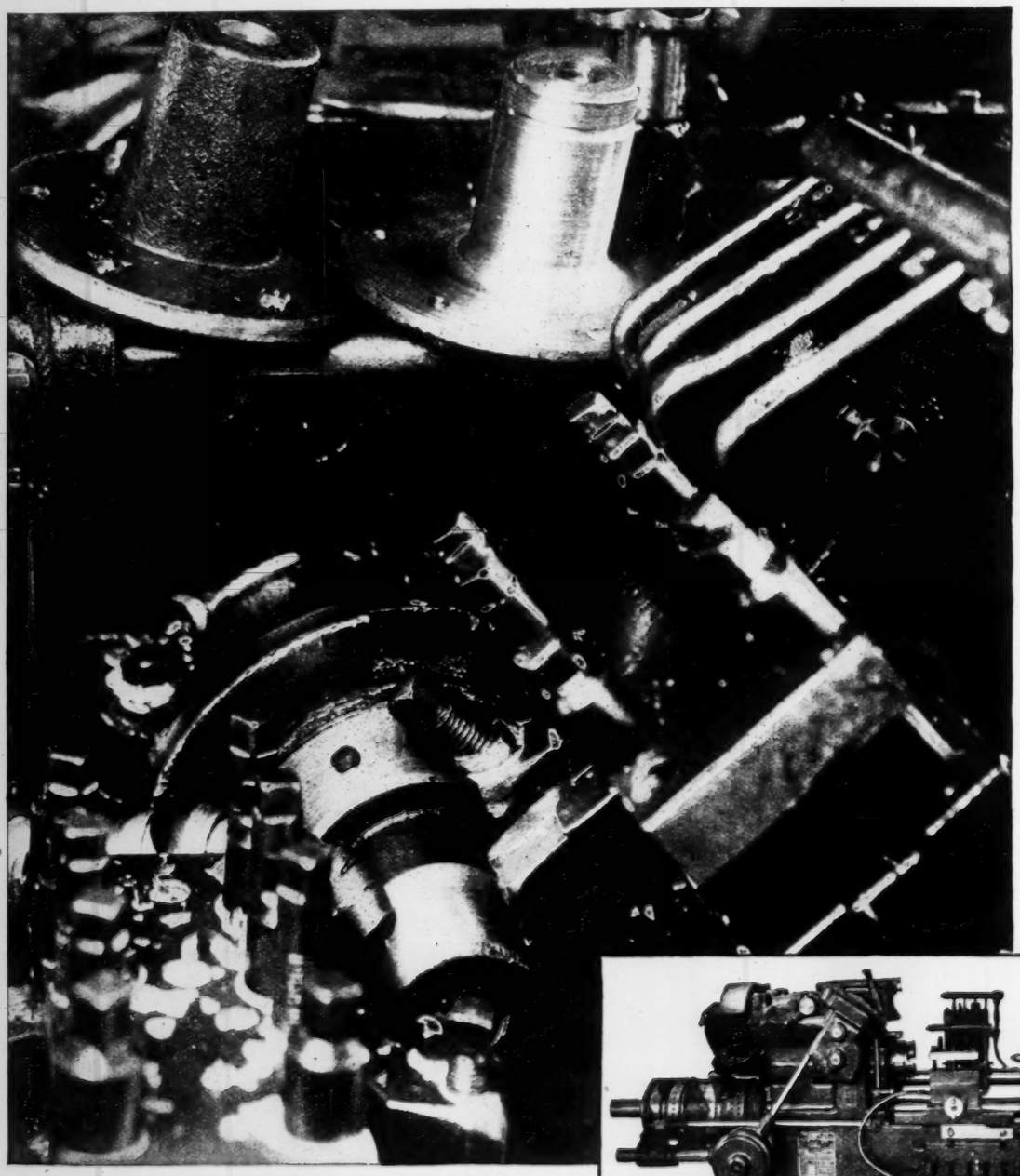
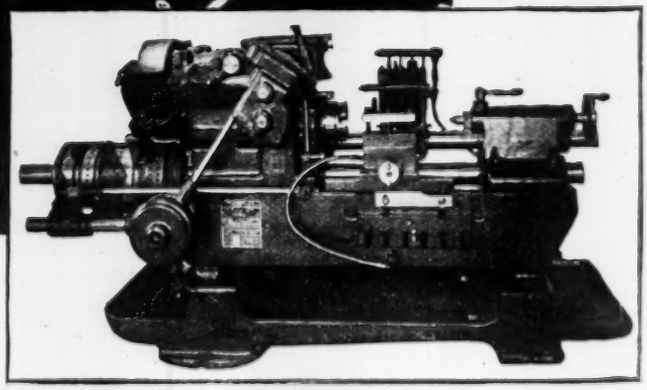
230 Ford Truck Rear Hubs





The above photograph was taken at the plant of a prominent automobile parts manufacturing corporation and shows a close-up of one of a battery of Fay Automatic Lathes finish turning Ford Truck Rear Hubs.

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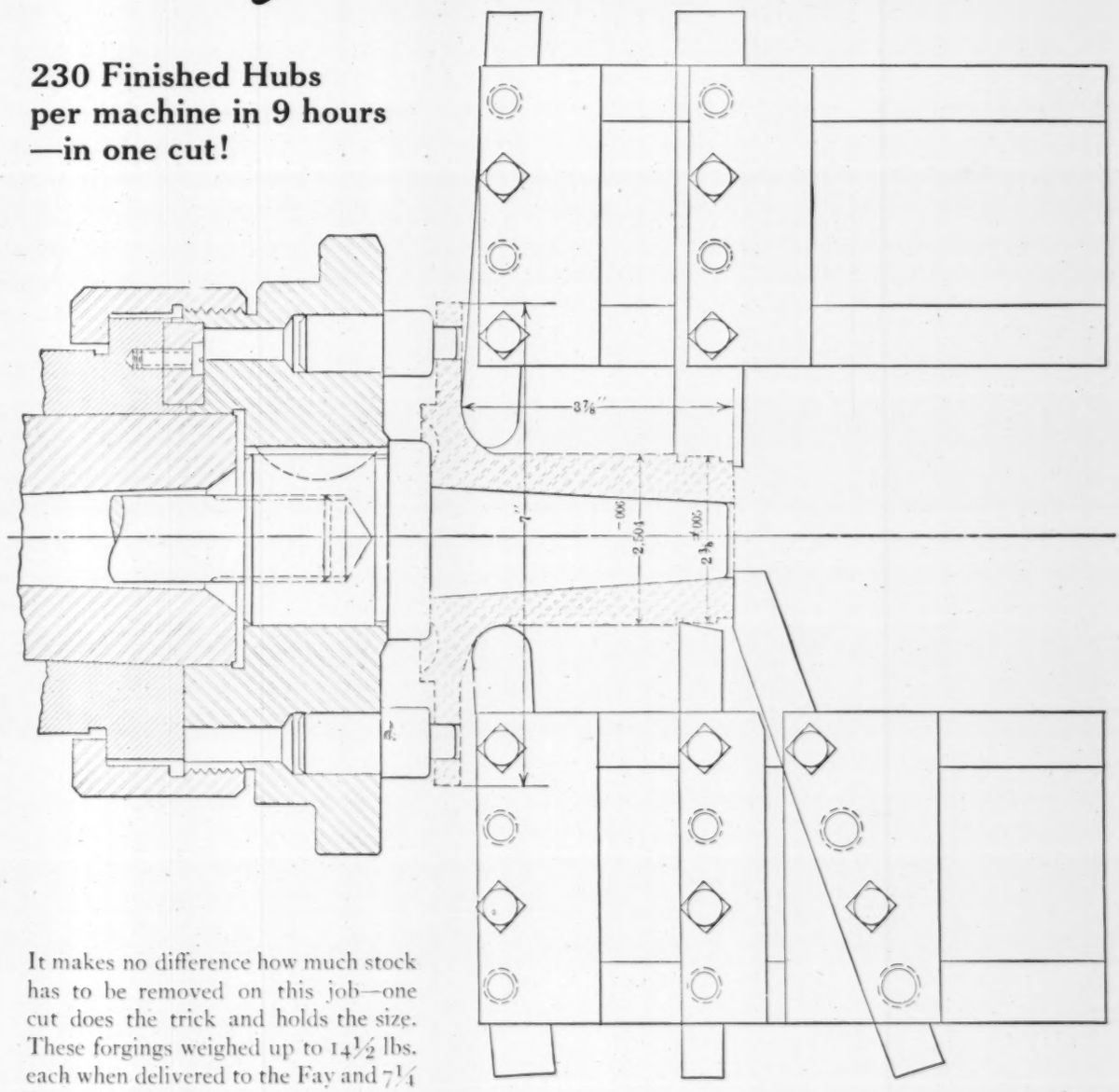
230 Finished Hubs per machine in 9 hours —in one cut!



It makes no difference how much stock has to be removed on this job—one cut does the trick and holds the size. These forgings weighed up to 14½ lbs. each when delivered to the Fay and 7¼ lbs. each after being turned as shown.

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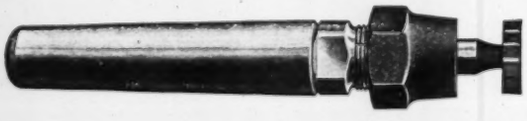

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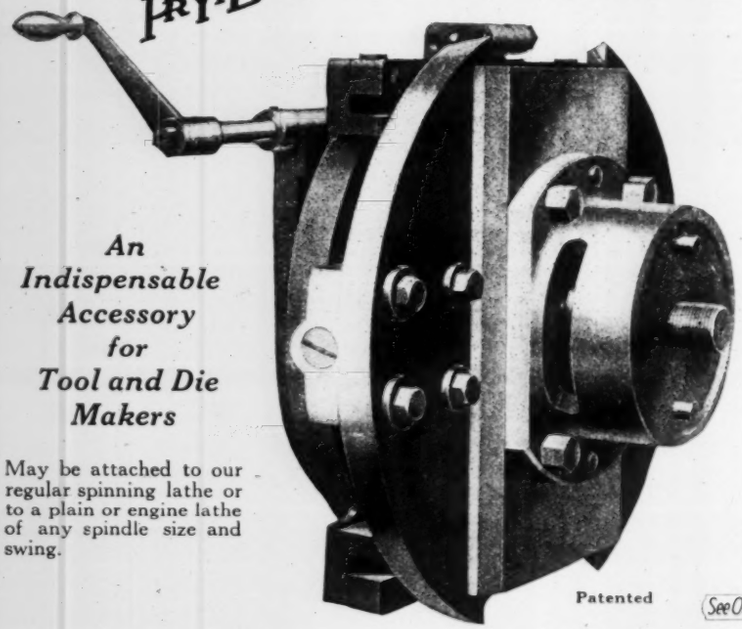

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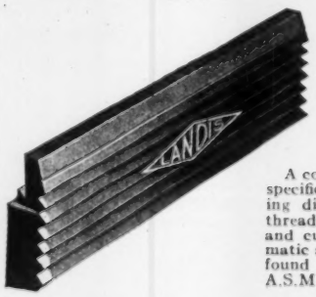

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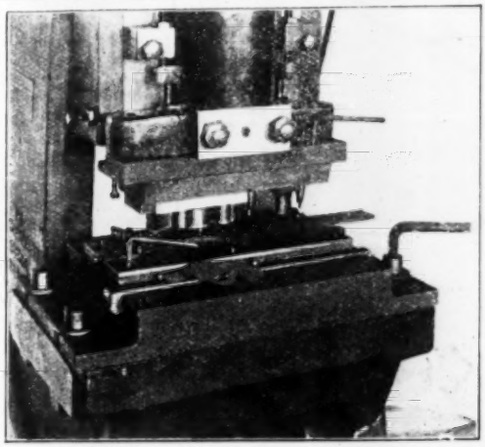

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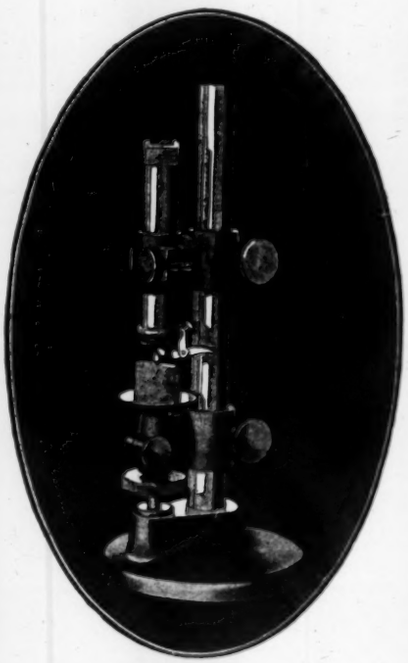

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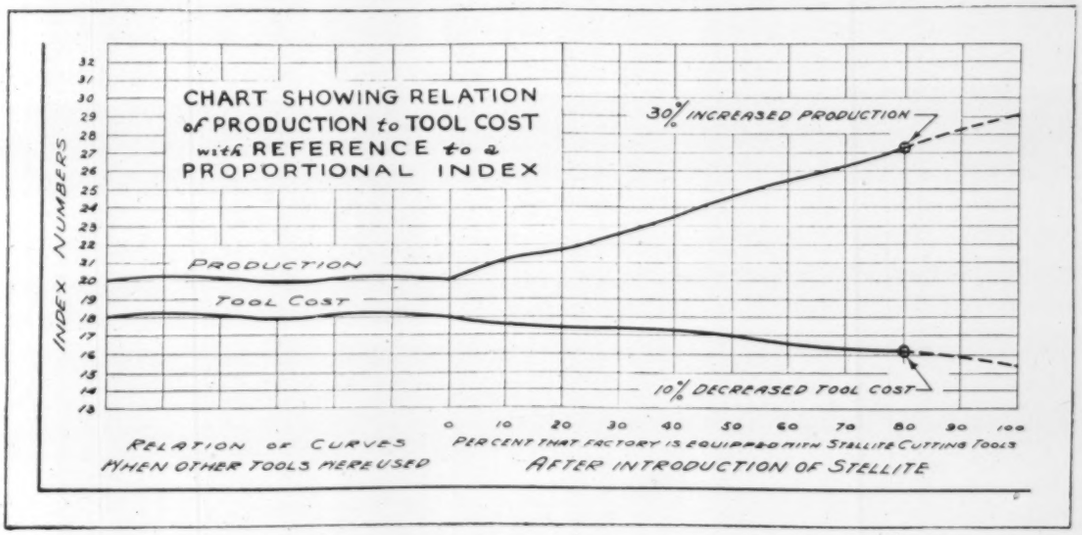

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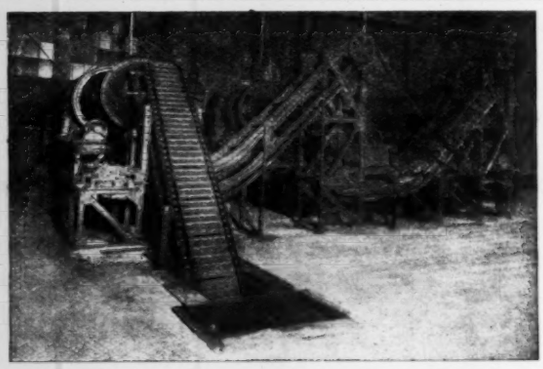

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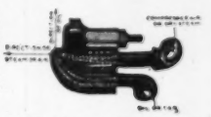

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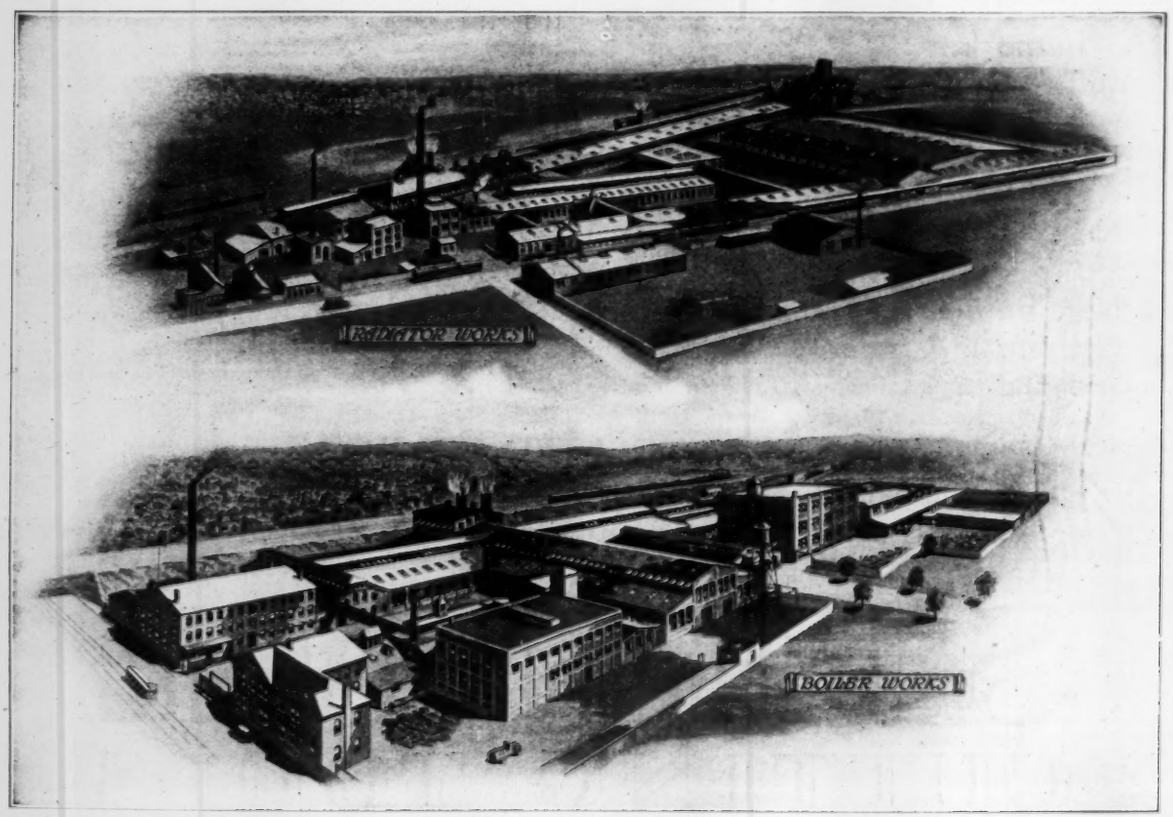

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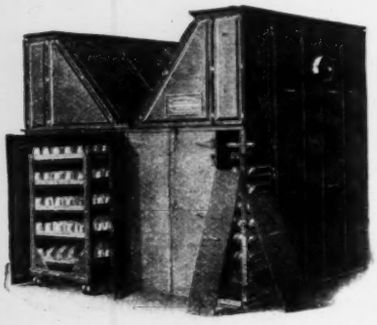

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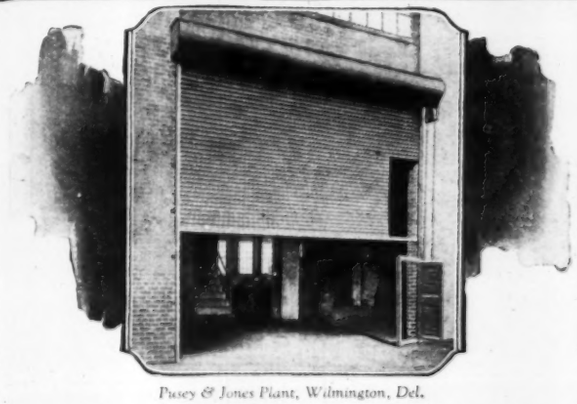

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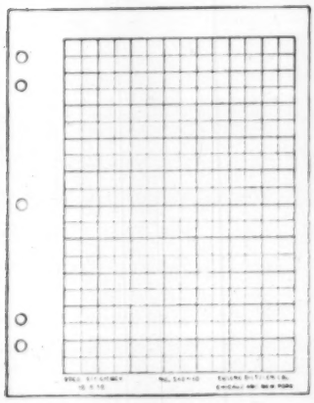

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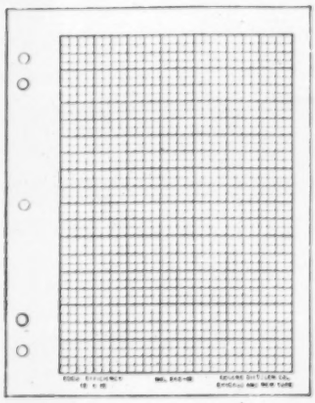

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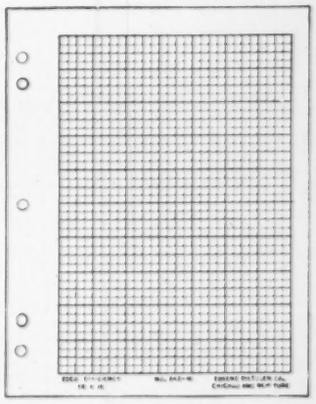

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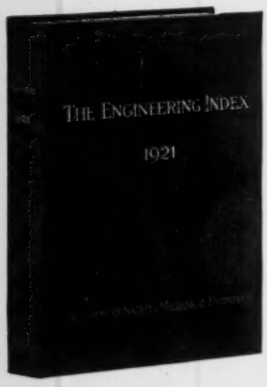

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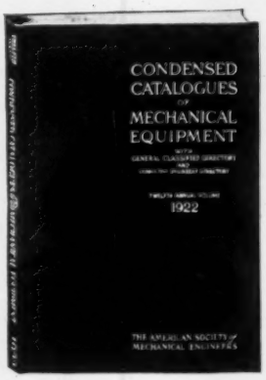

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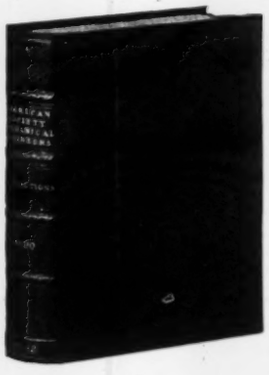

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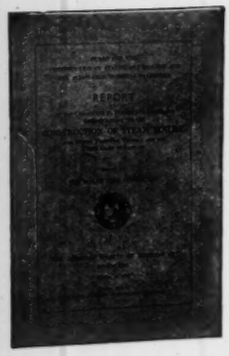

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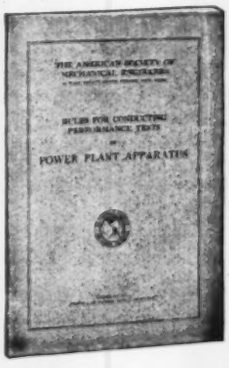

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The Evolution of Low-lift Pumping Plants in the Gulf Coast Country	W. B. Gregory	1534	.50	.65
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Mackintosh-Hemphill Co.
* Worthington Pump & Mchy. Corp'n

Aerial Tramways
(See Tramways, Wire Rope)

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(See Compressors, Receivers, etc., Air)

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* Spray Engineering Co.

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(See Generators, Electric)

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* General Electric Co.
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(See Condensers, Fittings, etc., Ammonia)

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* Titusville Iron Works Co.

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* Medart Co

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* King Refractories Co. (Inc.)

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Brinckerhoff, H. Gordon Co.

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Balls, Steel
* Gwilliam Co.
* S K F Industries (Inc.)

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Taylor Instrument Cos.

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Fafnir Bearing Co.
Gurney Ball Bearing Co.
* Gwilliam Co.
* Norma Co. of America
* S K F Industries (Inc.)
* U. S. Ball Bearing Mfg. Co.

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American Crucible Products Co.
Phosphor Bronze Smelting Co.

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* Norma Co. of America
* Royersford Fdy. & Mch. Co.
* Timken Roller Bearing Co.
* U. S. Ball Bearing Mfg. Co

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* Falls Clutch & Machinery Co.
* Jones, W. A. Foundry & Machine Co.
* Royersford Fdy. & Mch. Co.
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Leather Belting Exchange

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* Smidth, F. L. & Co.
* Wood's, T. B. Sons Co.

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(See Chain Belts and Links)

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* Kerr Turbine Co.

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(See Compounds, Boiler)

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(See Coverings, Furnaces, Tube Cleaners, Etc., Boiler)

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* Springfield Boiler Co.
* Titusville Iron Works Co.
* Walsh & Weidner Boiler Co.
* Ward, Charles Engineering Wks.

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* Leffel, James & Co.
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* O'Brien, John Boiler Works Co.
* Titusville Iron Works Co.
Union Iron Works
* Walsh & Weidner Boiler Co.

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* Casey-Hedges Co.
* Cole, R. D. Mfg. Co.
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Herbert Boiler Co.
* Keeler, E. Co.
* Leffel, James & Co.
Lidgerwood Mfg. Co.
* O'Brien, John Boiler Works Co.
* Titusville Iron Works Co.
Union Iron Works
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* Walsh & Weidner Boiler Co.
* Ward, Charles Engineering Wks.
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* Ladd, George T. Co.
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* Vogt, Henry Machine Co.
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Rockwell, W. S. Co.
* Schutte & Koerting Co.
* Spray Engineering Co.

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Manufacturing Equipment & Engrg. Co.

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(See Railways, Cable)

Cable Wire
(See Rope, Wire)

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(See Wire & Cables, Electrical)

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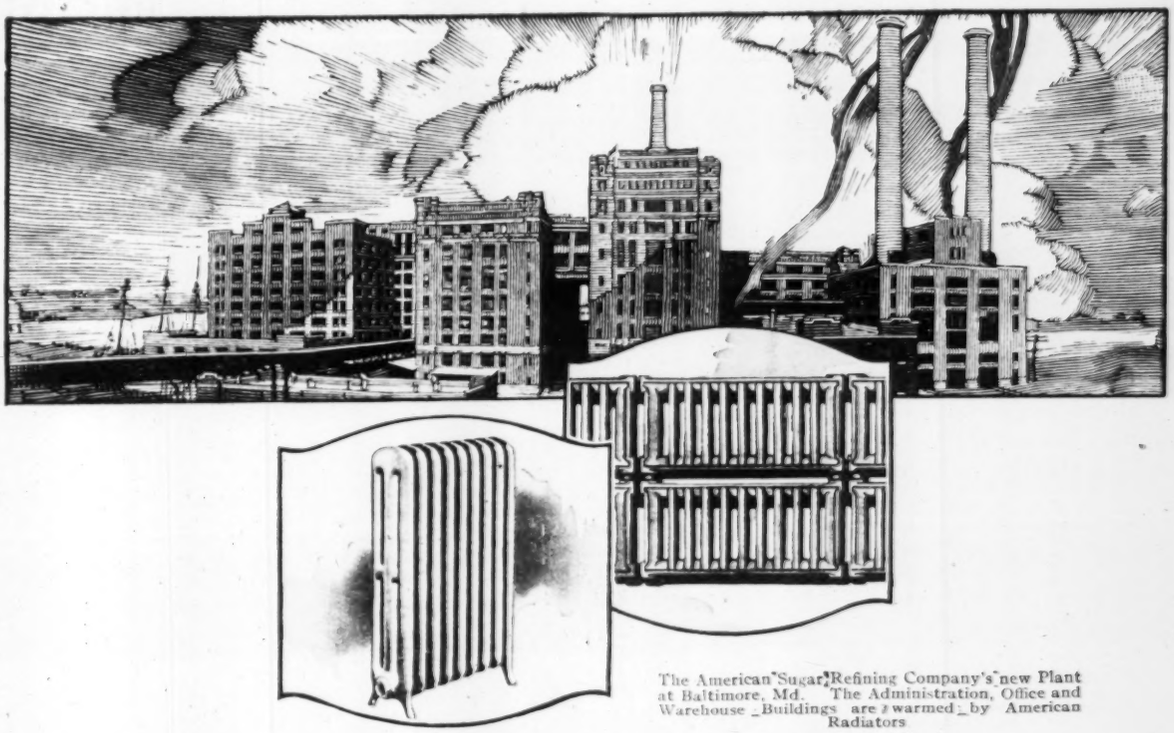
Lidgerwood Mfg. Co.

*Catalogue data of firms marked * appear in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1922 Volume*



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Lidgerwood Mfg. Co.

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* Sarco Co. (Inc.)
* Schaeffer & Budenberg Mfg. Co.

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* Hooven, Owens, Rentschler Co.
* Jones, W. A. Foundry & Machine Co.
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* Lunkenheimer Co.
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* Royersford Fdry. & Mch. Co.
* United States Cast Iron Pipe & Fdry. Co.
* Vogt, Henry Machine Co.

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Driver-Harris Co. (in Canada)

Castings, Nichrome
Driver-Harris Co.

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* Hooven, Owens, Rentschler Co.
* Lunkenheimer Co.
* Vogt, Henry Machine Co.

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Castings, White Metal
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(See Blowers, Pumps, etc., Centrifugal)

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Tolhurst Machine Works

Centrifugals, Metal Drying
Tolhurst Machine Works

Centrifugals, Sugar
Tolhurst Machine Works
* Worthington Pump & Mchy. Corp'n

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* Gifford-Wood Co.
* Jones, W. A. Foundry & Machine Co.
Union Chain & Mfg. Co.
* Whitney Mfg. Co.

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(See Stokers, Chain Grate)

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Reading Chain & Block Corp'n

Chains, Crane
Reading Chain & Block Corp'n

Chains, Power Transmission
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* Diamond Chain & Mfg. Co.
* Morse Chain Co.
Union Chain & Mfg. Co.
* Whitney Mfg. Co.

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* Parker Supply Co.

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Heine Chimney Co.

Chimneys, Concrete
* American Chimney Corp'n
Heine Chimney Co.

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(See Stacks, Steel)

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* Warner & Swasey Co.

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* Whitney Mfg. Co.

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(See Mills, Cinder)

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* Medart Co.
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* Gifford-Wood Co.
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* Shepard Electric Crane & Hoist Co.

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* Brown Hoisting Machinery Co.

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Coal Mining Machinery
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* Ingersoll-Rand Co.

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* Jenkins Bros.
* Lunkenheimer Co.
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* Vogt, Henry Machine Co.

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Cadman, A. W. Mfg. Co.
* Crane Co.
* Lunkenheimer Co.
* Reading Steel Casting Co. (Inc.) (Pratt & Cady Division)

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* American Steam Gauge & Valve Mfg. Co.
* Crane Co.
* Crosby Steam Gage & Valve Co.
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Norwalk Iron Works Co.
* Titusville Iron Works Co.
* Worthington Pump & Machinery Corp'n

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* De Laval Steam Turbine Co.
* General Electric Co.

Compressors, Air, Compound
* Ingersoll-Rand Co.
* Worthington Pump & Machinery Corp'n

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* Ingersoll-Rand Co.
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.
* Worthington Pump & Machinery Corp'n

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* General Electric Co.
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* Vogt, Henry Machine Co.

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* Ingersoll-Rand Co.
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* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engineering Co.
* Worthington Pump & Machinery Corp'n

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Buffalo Steam Pump Co.
Elliott Co.
* Ingersoll-Rand Co.
* Schutte & Koerting Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engineering Co.
* Worthington Pump & Machinery Corp'n

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Elliott Co.
* Ingersoll-Rand Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engineering Co.
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* Johns-Manville (Inc.)

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(See Regulators)

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* Gifford-Wood Co.
* Jones, W. A. Fdry. & Mach. Co.

Conveyors, Ice
* Gifford-Wood Co.

Conveyors, Screw
* Gifford-Wood Co.

Coolers, Brine
* Frick Co. (Inc.)

Cooling Ponds, Spray
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* Cooling Tower Co. (Inc.)
* Schutte & Koerting Co.
* Spray Engineering Co.

Cooling Towers
* Burhorn, Edwin Co.
* Cooling Tower Co. (Inc.)
* Spray Engineering Co.
* Wheeler, C. H. Mfg. Co.
* Worthington Pump & Machinery Corp'n

Copper, Drawn
* Roebling's, John A. Sons Co.

Copper Converting Machinery
* Allis-Chalmers Mfg. Co.
* Worthington Pump & Machinery Corp'n

Copper Work
* Badger, E. B. & Sons Co.

Corliss Engines
(See Engines, Steam, Corliss)

Counters, Revolution
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
* Bristol Co.
* Crosby Steam Gage & Valve Co.
* Schaeffer & Budenberg Mfg. Co.
Veeder Mfg. Co.

Countershafts
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* Wood's, T. B. & Sons Co.

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* Crane Co.
* Lunkenheimer Co.

Couplings, Shaft (Flexible)
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* Fawcus Machine Co.
* Hooven, Owens, Rentschler Co.
* Jones, W. A. Foundry & Machine Co.
* Medart Co.
Smith & Serrell

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* Falls Clutch & Machinery Co.
* General Electric Co.
* Hooven, Owens, Rentschler Co.
* Jones, W. A. Foundry & Machine Co.
* Medart Co.
* Royersford Foundry & Machine Co.
Smith & Serrell
* Wood's, T. B. Sons Co.

Couplings, Union
(See Unions)

Couplings, Universal Joint
* Wood's, T. B. Sons Co.

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* Johns-Manville (Inc.)

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Northern Engineering Works
* Shepard Electric Crane & Hoist Co.

Cranes, Floor (Portable)
Lidgerwood Mfg. Co.

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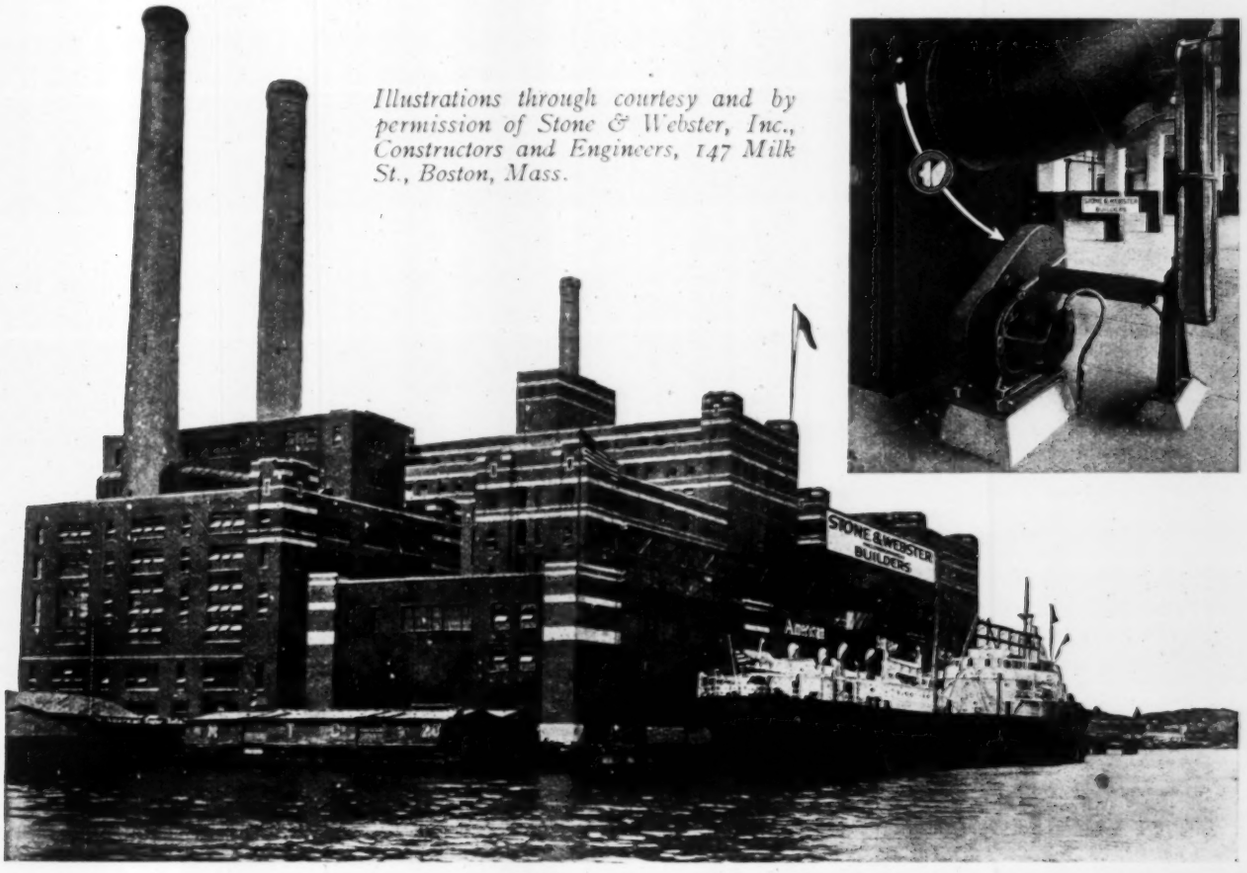

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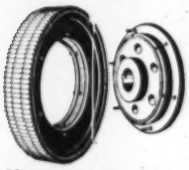

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* Brown Hoisting Machinery Co.

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* Brown Hoisting Machinery Co.
Northern Engineering Works

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Crushers, Roll
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(See Regulators, Damper)

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(See Castings, Die Moulded)

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* Carrier Engineering Corp'n
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* Allis-Chalmers Mfg. Co.
Clarage Fan Co.

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* Allis-Chalmers Mfg. Co.

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Sonneborn, L. Sons (Inc.)

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(See Balancing Machines, Dynamic)

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Ejectors
* Lunkenheimer Co.
* Schutte & Koerting Co.

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(See Generators, Hoists, Trucks, Welding, etc., Electric)

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* Allis-Chalmers Mfg. Co.
* General Electric Co.

Electric Measuring Instruments
(See Instruments, Electrical Measuring)

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* Johns-Manville (Inc.)

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* Jones, W. A. Fdry. & Mach. Co.

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Northern Engineering Works

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Otis Elevator Co.

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Northern Engineering Works
Otis Elevator Co.

Emery Wheel Dressers
* Builders Iron Foundry

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* Franklin Machine Co.

Engine Stops
* Schutte & Koerting Co.

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(See Professional Engineering Service Section)

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* Hooven, Owens, Rentschler Co.
Mackintosh-Hemphill Co.
* Worthington Pump & Machinery Corp'n

Engines, Distillate
Western Machinery Co.

Engines, Gas
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* De La Vergne Machine Co.
* Hooven, Owens, Rentschler Co.
* Ingersoll-Rand Co.
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* Titusville Iron Works Co.
Western Machinery Co.
* Worthington Pump & Machinery Corp'n

Engines, Gasoline
* Climax Engineering Co.
Midwest Engine Corp'n
Otto Engine Works
* Titusville Iron Works Co.
Western Machinery Co.
* Worthington Pump & Machinery Corp'n

Engines, Hoisting
* Allis-Chalmers Mfg. Co.
* Climax Engineering Co.
Clyde Iron Works Sales Co.
Flory, S. Mfg. Co.
Lidgerwood Mfg. Co.
* Morris Machine Works
Western Machinery Co.

Engines, Kerosene
* Climax Engineering Co.
Western Machinery Co.
* Worthington Pump & Machinery Corp'n

Engines, Marine
* Climax Engineering Co.
* Hooven, Owens, Rentschler Co.
* Ingersoll-Rand Co.
Johnson, Carlyle Machine Co.
* Ward, Chas. Engineering Wks.
* Worthington Pump & Machinery Corp'n

Engines, Marine, Oil
Western Machinery Co.

Engines, Oil
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* De La Vergne Machine Co.
* Ingersoll-Rand Co.
Midwest Engine Corp'n
Otto Engine Works
* Titusville Iron Works Co.
Western Machinery Co.
* Worthington Pump & Machinery Corp'n

Engines, Oil, Diesel
* Allis-Chalmers Mfg. Co.
* Climax Engineering Co.
Midwest Engine Corp'n.
Western Machinery Co.
* Worthington Pump & Machinery Corp'n

Engines, Pumping
* Allis-Chalmers Mfg. Co.
* Climax Engineering Co.
* Hooven, Owens, Rentschler Co.
* Ingersoll-Rand Co.
* Morris Machine Works
Western Machinery Co.
* Worthington Pump & Machinery Corp'n

Engines, Steam
* Allis-Chalmers Mfg. Co.
* Brownell Co.
Clarage Fan Co.
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* Cole, R. D. Mfg. Co.
* Engberg's Electric & Mech. Wks.
* Erie City Iron Works
* Hooven, Owens, Rentschler Co.
* Ingersoll-Rand Co.
* Leffel, James & Co.
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Mackintosh-Hemphill Co.
* Morris Machine Works
* Ridgway Dynamo & Engine Co.
* Titusville Iron Works Co.
* Troy Engine & Machine Co.
* Vilter Mfg. Co.
* Wheeler, C. H. Mfg. Co.

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* American Blower Co.
* Brownell Co.
Clarage Fan Co.
* Engberg's Electric & Mech. Wks.
* Erie City Iron Works
* Leffel, James & Co.
* Troy Engine & Machine Co.

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* Allis-Chalmers Mfg. Co.
* Franklin Machine Co.
* Frick Co. (Inc.)
* Hooven, Owens, Rentschler Co.
Mackintosh-Hemphill Co.
* Vilter Mfg. Co.

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* American Blower Co.
* Brownell Co.
Clarage Fan Co.
* Engberg's Electric & Mech. Wks.
* Erie City Iron Works

Engines, Steam, Poppet Valve
* Erie City Iron Works
* Vilter Mfg. Co.

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* Brownell Co.
Clarage Fan Co.
* Engberg's Electric & Mech. Wks.

Engines, Steam, Una-Flow
* Frick Co. (Inc.)
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Stumpf Una-Flow Engine Co (Inc.)

Engines, Steam, Variable Speed
* Brownell Co.

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* Engberg's Electric & Mech. Wks.
* Troy Engine & Machine Co.

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* Vogt, Henry Machine Co.

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Flory, S. Mfg. Co.
Lidgerwood Mfg. Co.

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* American Blower Co.
Clarage Fan Co.

Exhausters, Gas
Clarage Fan Co.
* General Electric Co.
* Green Fuel Economizer Co.
* Schutte & Koerting Co.

Expansion Joints
(See Joints, Expansion)

Extractors, Centrifugal
Tolhurst Machine Works

Extractors, Oil and Grease
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* Kieley & Mueller (Inc.)

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Manufacturing Equipment & Engrg. Co.

Fans, Exhaust
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Clarage Fan Co.
* General Electric Co.
* Green Fuel Economizer Co.
Philadelphia Drying Machinery Co.

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Clarage Fan Co.

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(See Circulators, Heaters, Heaters and Purifiers, etc., Feed Water)

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(See Regulators, Feed Water)

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Combustion Engineering Corp'n
* Smidth, F. L. & Co.

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* Permutit Co.

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* Bowser, S. F. & Co. (Inc.)
(Richardson-Phenix Division)
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Filters, Pressure
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Filters, Water
Elliott Co.
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International Filter Co.
* Scaife, Wm. B. & Sons Co.

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(See Brick, Hydrants, Fire, etc.)

Fire Tube Boilers
(See Boilers, Return and Vertical Tubular)

Fittings, Ammonia
* Crane Co.
* De La Vergne Machine Co.
* Frick Co. (Inc.)
Martin-Morse Corp'n
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.

Fittings, Compression
* Bowser, S. F. & Co. (Inc.)
(Richardson-Phenix Division)

Fittings, Flanged
* Builders Iron Foundry
* Central Foundry Co.
* Crane Co.
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* Lunkenheimer Co.
Martin-Morse Corp'n
* Nelson Valve Co
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* Crane Co.
* Hydraulic Press Mfg. Co.
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Martin-Morse Corp'n
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* Vogt, Henry Machine Co.
Weatherly Foundry & Mfg. Co.

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* Crane Co.
* Lunkenheimer Co.
* Nelson Valve Co.
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* Medart Co.
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Forges, Rivet
Rockwell, W. S. Co.

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* Vogt, Henry Machine Co.

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Northern Engineering Works

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(See Clutches, Hoists, etc., Friction)

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(See Economizers, Fuel)

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Furnace Engineering Co.

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(See Linings, Furnace)

Furnaces, Annealing and Tempering
* Best, W. N. Furnace & Burner Corp'n
* General Electric Co.
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Rockwell, W. S. Co.

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* American Engineering Co.
* American Spiral Pipe Wks.
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* Bernitz Furnace Appliance Co.
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* Combustion Engineering Corp'n
* Detroit Stoker Co.
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Kenworthy, Chas. F. (Inc.)

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Furnaces, Hardening
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* General Electric Co.
Rockwell, W. S. Co.

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Rockwell, W. S. Co.

Furnaces, Non-Oxidizing
Kenworthy, Chas. F. (Inc.)

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Rockwell, W. S. Co.

Furnaces, Smokeless
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* Babcock & Wilcox Co.
* Combustion Engineering Corp'n
* Detroit Stoker Co.
* Gibby Engineering Co.
Green Engineering Co.
Herbert Boiler Co
* Illinois Stoker Co.
* Murphy Iron Works
* Riley, Sanford Stoker Co

Fuses
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* Johns-Manville (Inc.)

Gage Boards
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
* Crosby Steam Gage & Valve Co.
* Schaeffer & Budenberg Mfg. Co.

Gage Glasses
* Schaeffer & Budenberg Mfg. Co.

Gage Testers
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
* Crosby Steam Gage & Valve Co.
* Schaeffer & Budenberg Mfg. Co.

Gages, Altitude
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
* Crosby Steam Gage & Valve Co
* Schaeffer & Budenberg Mfg. Co.

Gages, Ammonia
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
* Crosby Steam Gage & Valve Co.
* Schaeffer & Budenberg Mfg. Co.
* Vogt, Henry Machine Co.

Gages, Ball
* S K F Industries (Inc.)

Gages, Differential Pressure
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Precision Instrument Co.
* Schaeffer & Budenberg Mfg. Co.
* Uehling Instrument Co.

Gages, Draft
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
Brinckerhoff, H. Gordon Co.
* Bristol Co.
* Precision Instrument Co.
* Schaeffer & Budenberg Mfg. Co.
Taylor Instrument Cos.
* Uehling Instrument Co.

Gages, Hydraulic
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
* Crosby Steam Gage & Valve Co.
* Hydraulic Press Mfg. Co.
* Schaeffer & Budenberg Mfg. Co.

Gages, Liquid Level
* Bristol Co.
* Lunkenheimer Co.
* Precision Instrument Co.
* Simplex Valve & Meter Co.

Gages, Loss of Head
* Builders Iron Foundry
* Simplex Valve & Meter Co.

Gages, Measuring (Surface, Depth, Dial, etc.)
* Norma Co. of America
* S K F Industries (Inc.)

Gages, Pressure
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Bristol Co.
* Crosby Steam Gage & Valve Co.
* Precision Instrument Co.
* Schaeffer & Budenberg Mfg. Co.
* Uehling Instrument Co

Gages, Rate of Flow
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Builders Iron Foundry
* Precision Instrument Co.
* Simplex Valve & Meter Co.

Gages, Vacuum
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
Brinckerhoff, H. Gordon Co.
* Bristol Co.
* Crosby Steam Gage & Valve Co.
* Precision Instrument Co.
* Schaeffer & Budenberg Mfg. Co.
Taylor Instrument Cos.
* Uehling Instrument Co.

Gages, Water
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
* Bristol Co.
* Crane Co.
* Jenkins Bros.
* Lunkenheimer Co.
* Reading Steel Casting Co. (Inc.) (Pratt & Cady Division)
* Simplex Valve & Meter Co.

Gages, Water Level
* Bristol Co.
* Schaeffer & Budenberg Mfg. Co.
* Simplex Valve & Meter Co.

Gas Analysis Apparatus
* Precision Instrument Co.

Gas Burners, Compressors, Engines, Exhausters, Producers, etc.
(See Burners, Compressors, Engines, Exhausters, Producers, etc., Gas)

Gas Burning Equipment
Rockwell, W. S. Co.

Gas Collectors
* Precision Instrument Co.

Gas Plant Machinery
* Cole, R. D. Mfg. Co.
Rockwell, W. S. Co.

Gaskets
* Goetze Gasket & Packing Co.
* Jenkins Bros.
* Johns-Manville (Inc.)
* Sarco Co. (Inc.)

Gasoline
Texas Co.
* Tide Water Oil Sales Corp'n

Gates, Blast
Rockwell, W. S. Co.

Gates, Sluice
* Chapman Valve Mfg. Co.

Gear Cutting Machines
* Jones, W. A. Fdry. & Mch. Co.

Gear Hobbing Machines
* Jones, W. A. Fdry. & Mch. Co.

Gears, Cut
Brown, A. & F. Co.
* De Laval Steam Turbine Co.
* Fawcus Machine Co.
* Foote Bros. Gear & Machine Co.
Hindley Gear Co.
* James, D. O. Mfg. Co.
Johnson, Carlyle Machine Co.
* Jones, W. A. Fdry. & Mch. Co.
Mackintosh-Hemphill Co.
* Medart Co.
Northern Engineering Works

Gears, Fibre
* General Electric Co.
* James, D. O. Mfg. Co.

Gears, Machine Moulded
Brown, A. & F. Co.
* Jones, W. A. Fdry. & Mch. Co.

Gears, Rawhide
* James, D. O. Mfg. Co.

Gears, Speed Reduction
* De Laval Steam Turbine Co.
* Fawcus Machine Co.
* Foote Bros. Gear & Machine Co.
* General Electric Co.
* James, D. O. Mfg. Co.
* Jones, W. A. Fdry. & Mch. Co.
* Kerr Turbine Co.
* Moore Steam Turbine Corp'n

Gears, Worm
* Cleveland Worm & Gear Co.
* Fawcus Machine Co.
* Foote Bros. Gear & Machine Co.
* Gifford-Wood Co.
Hindley Gear Co.
* James, D. O. Mfg. Co.
* Jones, W. A. Fdry. & Mach. Co.

Generating Sets
* Allis-Chalmers Mfg. Co.
* American Blower Co.
Clarage Fan Co.
* De Laval Steam Turbine Co.
* Engberg's Electric & Mech. Wks.
* General Electric Co.
* Kerr Turbine Co.
Midwest Engine Corp'n

Generators, Electric
* Allis-Chalmers Mfg. Co.
* De Laval Steam Turbine Co.
* Engberg's Electric & Mech. Wks.
* General Electric Co.
* Ridgway Dynamo & Engine Co.

Governors, Gas
Equitable Meter Co.

Governors, Pump
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)
Davis, G. M. Regulator Co.
* Illinois Engineering Co.
* Kieley & Mueller (Inc.)

Governors, Water Wheel
* Worthington Pump & Machinery Corp'n

Granulators
* Smidth, F. L. & Co.

Graphite, Flake (Lubricating)
* Dixon, Joseph Crucible Co.

Grate Bars
* Casey-Hedges Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* McClave Brooks Co.
* Titusville Iron Works Co.
* Vogt, Henry Machine Co.

Grate Bars (for Overfeed and Underfeed Stokers)
Furnace Engineering Co.

Grates, Dumping
* Brownell Co.
* Combustion Engineering Corp'n
* McClave Brooks Co.
* Titusville Iron Works Co.
* Vogt, Henry Machine Co.

Grates, Kiln
* McClave Brooks Co.

Grates, Rocking
* Brownell Co.

Grates, Shaking
* Brownell Co.
* Casey-Hedges Co.
* Combustion Engineering Corp'n
* Erie City Iron Works
* McClave Brooks Co.
* Springfield Boiler Co.
* Titusville Iron Works Co.
* Vogt, Henry Machine Co.

Grease Cups
(See Oil and Grease Cups)

Grease Extractors
(See Separators, Oil)

Greases
Dixon, Joseph Crucible Co.
* Royersford Foundry & Machine Co.
Texas Co.
* Tide Water Oil Sales Corp'n
Vacuum Oil Co.

Grinding Machinery
Brown, A. & F. Co.
* Smidth, F. L. & Co.

Grinding Machines, Chaser
* Landis Machine Co. (Inc.)

Grinding Machines, Floor
* Builders Iron Foundry
* Royersford Foundry & Machine Co.

Grinding Machines, Internal
* Heald Machine Co.

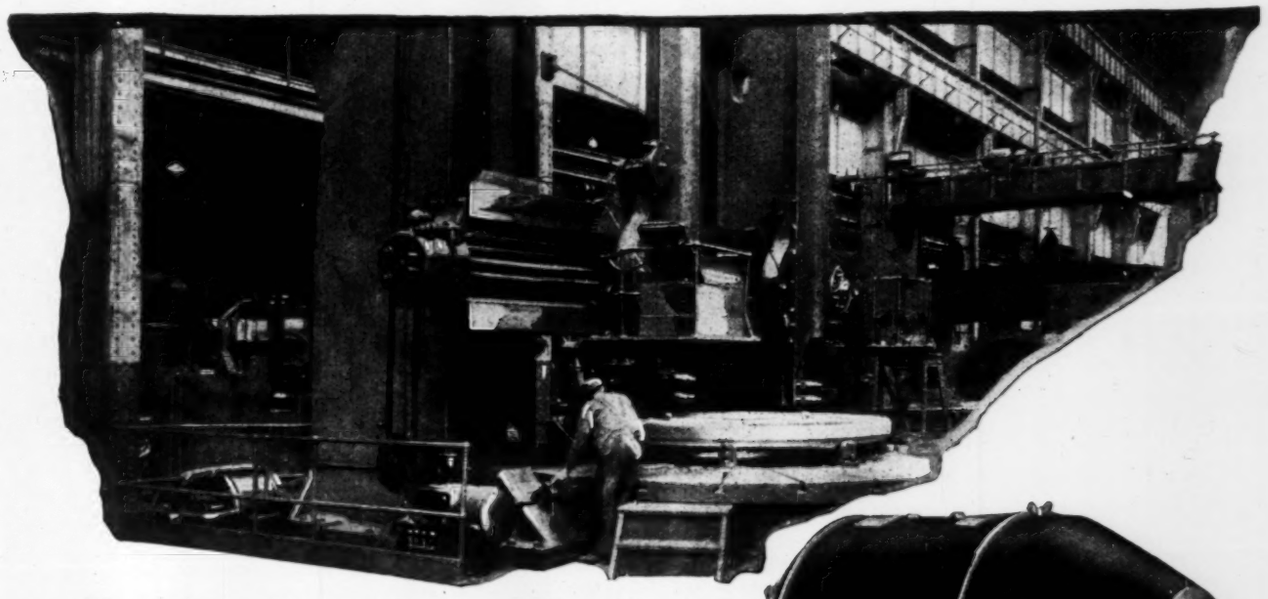
Grinding Machines, Surface
* Heald Machine Co.

Gun Metal Finish
* American Metal Treatment Co.

Hammers, Drop
* Bliss, E. W. Co.
* Franklin Machine Co.
Long & Allstatter Co.

Hammers, Pneumatic
* Ingersoll-Rand Co.

Ease and accuracy of operating Boring Mills is obtained by their complete electrical equipment



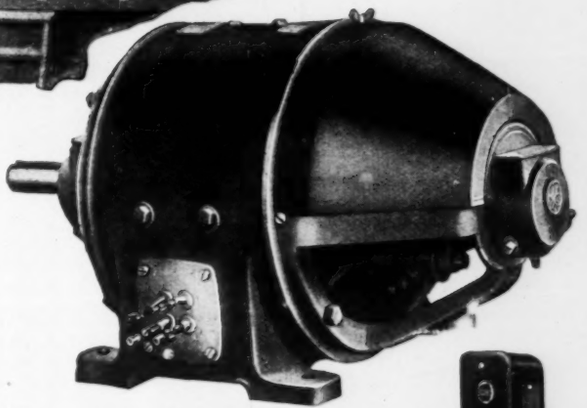
Positive Control at a Touch

Electrical control of this big machine from points within convenient reach gives the operator full command of its operations. Such control is a part of the General Electric Company's complete electrical equipment for Boring Mills—which includes main driving and auxiliary direct-current motors, contactor panels for each motor, and control stations.

The electric motor could not have worked its wonders without handy provision to start, jog, reverse, regulate speed, brake, and stop at a moment's notice—all due to proper control. Even the big machines have thus been made safe and flexible to operate.

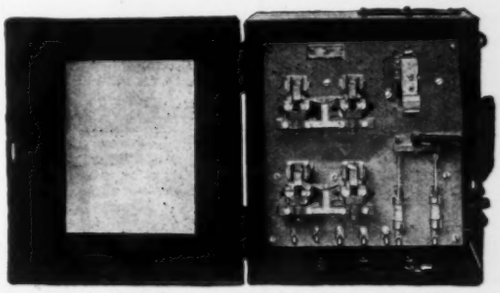
A feature of this G-E equipment is the Magnetic Controller, actuated by Push Button Station, which permits a flexibility of operation of Boring Mills which cannot be obtained by any other method.

With Magnetic Control it is only necessary to locate the Push Button at some point convenient for the operator, thus facilitating operation. The Push Button Station may be used as a pendent switch, permitting the operator to control his machine even from inside the casting on the table.



G-E Type RC Direct-Current Motor for auxiliary drives has solid top half covers which protect the motor from dust and dirt

G-E Push Button Station for actuating Magnetic Controllers



G-E Magnetic Controller (small panel for auxiliary drive)—all units assembled in sheet metal enclosing case

General Electric Company

General Office Schenectady, N.Y.

Sales Offices in all large cities

GB-60

CLASSIFIED LIST OF MECHANICAL EQUIPMENT (Continued) FOR ALPHABETICAL INDEX, SEE PAGE 134

Hangers, Shaft
Brown, A. & F. Co.
* Falls Clutch & Machinery Co.
* Jones, W. A. Fdry. & Mach. Co.
* Medart Co.
* Royersford Foundry & Machine Co.
* Wood's, T. B. Sons Co.

Hangers, Shaft (Ball and Roller Bearing)
* Jones, W. A. Fdry. & Mach. Co.
* S K F Industries (Inc.)

Hardening
* American Metal Treatment Co.
Rockwell, W. S. Co.

Heat Treating
* American Metal Treatment Co.
Rockwell, W. S. Co.

Heaters, Feed Water (Closed)
* Brownell Co.
* Erie City Iron Works
* Schutte & Koerting Co.
* Walsh & Weidner Boiler Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engineering Co.
* Worthington Pump & Machinery Corp'n

Heaters, Feed Water, Locomotive (Open)
* Worthington Pump & Machinery Corp'n

Heaters, Water Supply
Herbert Boiler Co.

Heaters, Water Supply (Garbage Burner)
Herbert Boiler Co.

Heaters & Mixers, Water, Instantaneous
Manufacturing Equipment & Engrg. Co.

Heaters and Purifiers, Feed Water (Open)
* Brownell Co.
Elliott Co.
* Erie City Iron Works
* H.S.B.W.-Cochrane Corp'n
* Springfield Boiler Co.
* Wickes Boiler Co.
* Worthington Pump & Machinery Corp'n

Heaters and Purifiers, Feed Water Metering
* H.S.B.W.-Cochrane Corp'n

Heating Systems, Vacuum
* Illinois Engineering Co.

Heating and Ventilating Apparatus
* American Blower Co.
* American Radiator Co.
Clarage Fan Co.

Hoisting and Conveying Machinery
* Brown Hoisting Machinery Co.
Clyde Iron Works Sales Co.
* Gifford-Wood Co.
* Jones, W. A. Fdry. & Mach. Co.
Lidgerwood Mfg. Co.
Northern Engineering Works
* Shepard Electric Crane & Hoist Co.

Hoists, Air
* Ingersoll-Rand Co.
Northern Engineering Works
* Shepard Electric Crane & Hoist Co.

Hoists, Belt
Clyde Iron Works Sales Co.
Lidgerwood Mfg. Co.

Hoists, Chain
Northern Engineering Works
Reading Chain & Block Corp'n

Hoists, Electric
* Allis-Chalmers Mfg. Co.
* Brown Hoisting Machinery Co.
Clyde Iron Works Sales Co.
Flory, S. Mfg. Co.
* General Electric Co.
Lidgerwood Mfg. Co.
Northern Engineering Works
Reading Chain & Block Corp'n
* Shepard Electric Crane & Hoist Co.

Hoists, Friction
Brown Clutch Co.
Eastern Machinery Co.

Hoists, Gas and Gasoline
Flory, S. Mfg. Co.
Lidgerwood Mfg. Co.
Western Machinery Co.

Hoists, Head Gate
Smith, S. Morgan Co.

Hoists, Mine
Flory, S. Mfg. Co.
Lidgerwood Mfg. Co.
Western Machinery Co.

Hoists, Skip
* Beaumont, R. H. Co.
* Brown Hoisting Machinery Co.
Flory, S. Mfg. Co.
Lidgerwood Mfg. Co.
Otis Elevator Co.

Hoists, Steam
(See Engines, Hoisting)

Holders, Nipple
Curtis & Curtis Co.

Hose, Metallic
* Johns-Manville (Inc.)

Humidifiers
* American Blower Co.
* Carrier Engineering Corp'n

Humidity Control
* American Blower Co.
* Carrier Engineering Corp'n

Hydrants, Fire
Kennedy Valve Mfg. Co.
* Reading Steel Casting Co. (Inc.) (Pratt & Cady Division)
* Worthington Pump & Machinery Corp'n

Hydraulic Machinery
* Allis-Chalmers Mfg. Co.
Hydraulic Press Mfg. Co.
* Ingersoll-Rand Co.
Mackintosh-Hemphill Co.
* Worthington Pump & Machinery Corp'n

Hydraulic Rams, Presses, Turbines, etc.
(See Rams, Presses, Turbines, etc., Hydraulic)

Hydrokineters
* Schutte & Koerting Co.

Hydrometers
Taylor Instrument Cos.

Hygrometers
Taylor Instrument Cos.

Ice Making Machinery
* De La Vergne Machine Co.
* Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Johns-Manville (Inc.)
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.

Ice Tools
* Gifford-Wood Co.

Idlers (Lenix)
* Smidth, F. L. & Co.

Indicator Posts
* Crane Co.
Kennedy Valve Mfg. Co.
* Reading Steel Casting Co. (Inc.) (Pratt & Cady Division)

Indicators, CO_2
Bacharach Industrial Instrument Co.
Brinckerhoff, H. Gordon Co.
* Precision Instrument Co.
* Uehling Instrument Co.

Indicators, Engine
* American Steam Gauge & Valve Mfg. Co.
Bacharach Industrial Instrument Co.
* Crosby Steam Gage & Valve Co.
* Schaeffer & Budenberg Mfg. Co.

Indicators, Sight Flow
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)

Indicators, Speed
* Schaeffer & Budenberg Mfg. Co.
Veeder Mfg. Co.
Weston Electrical Instrument Co.

Injectors
* Lunkenheimer Co.
* Schutte & Koerting Co.

Instruments, Electrical Measuring
* General Electric Co.
* Republic Flow Meters Co.
Taylor Instrument Cos.
Weston Electrical Instrument Co.

Instruments, Recording
* American Steam Gauge & Valve Mfg. Co.
* Ashton Valve Co.
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
Brinckerhoff, H. Gordon Co.
* Bristol Co.
* Builders Iron Foundry
* Crosby Steam Gage & Valve Co.
* General Electric Co.
* Precision Instrument Co.
* Republic Flow Meters Co.
* Schaeffer & Budenberg Mfg. Co.
Taylor Instrument Cos.
* Uehling Instrument Co.

Instruments, Scientific
Taylor Instrument Cos.

Instruments, Surveying
Dietzgen, Eugene Co.
Keuffel & Esser Co.

Insulating Materials (Electric)
* General Electric Co.
* Johns-Manville (Inc.)

Insulating Materials (Heat and Cold)
* Celite Products Co.
* Johns-Manville (Inc.)
* King Refractories Co. (Inc.)
* Quigley Furnace Specialties Co.

Irrigation Systems
* Spray Engineering Co.

Joints, Expansion
* Badger, E. B. & Sons Co.
* Crane Co.
* Illinois Engineering Co.
* Lunkenheimer Co.
* Wheeler, C. H. Mfg. Co.

Joints, Flanged Pipe
* Crane Co.

Joints, Flexible
* Barco Mfg. Co.

Joints, Swing and Swivel
* Barco Mfg. Co.

Kettles, Soda
Manufacturing Equipment & Engrg. Co.

Kettles, Steam Jacketed
* Cole, R. D. Mfg. Co.
* Titusville Iron Works Co.

Kerosene
* Tide Water Oil Sales Corp'n

Keys, Machine
* Whitney Mfg. Co.

Keyseating Machines
* Whitney Mfg. Co.

Kilns, Dry (Brick, Lumber, Stone, etc.)
* American Blower Co.

Ladles
Northern Engineering Works

Lamps, Incandescent
* General Electric Co.
* Johns-Manville (Inc.)

Land-Clearing Machinery
Clyde Iron Works Sales Co.

Lathe Attachments, Pipe-Threading
Curtis & Curtis Co.

Lathes, Automatic
* Jones & Lamson Machine Co.

Lathes, Brass
* Warner & Swasey Co.

Lathes, Chucking
* Jones & Lamson Machine Co.

Lathes, Engine
* Builders Iron Foundry

Lathes, Metal-Spinning
Pryibil, P. Machine Co.

Lathes, Turret
* Jones & Lamson Machine Co.
* Warner & Swasey Co.

Leather Belting, Packing, etc.
(See Belting, Packing, etc., Leather)

Levers, Flexible (Wire)
* Gwilliam Co.

Lightning Arresters
* General Electric Co.

Linings, Brake
* Johns-Manville (Inc.)

Linings, Furnace
* Best, W. N. Furnace & Burner Corp'n
Brinckerhoff, H. Gordon Co.
* Celite Products Co.
* Johns-Manville (Inc.)
* King Refractories Co. (Inc.)
* Quigley Furnace Specialties Co.

Linings, Stack
* Johns-Manville (Inc.)

Liquid Fuel Equipment
* Best, W. N. Furnace & Burner Corp'n

Loaders, Wagon
* Gifford-Wood Co.

Lockers, Metal
Manufacturing Equipment & Engrg. Co.

Lockers, Steel or Wood
Wilson, J. G. Corp'n

Locomotives, Electric
* General Electric Co.

Locomotives, Storage Battery
* General Electric Co.

Logging Machinery
Clyde Iron Works Sales Co.
Lidgerwood Mfg. Co.

Lubricants
* Royersford Fdry. & Mach. Co.
Texas Co.
* Tide Water Oil Sales Corp'n
Vacuum Oil Co.

Lubricating Systems
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)

Lubricators, Cylinder
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)
* Lunkenheimer Co.

Lubricators, Force-Feed
* Bowser S. F. & Co. (Inc.) (Richardson-Phenix Division)
* Lunkenheimer Co.

Lubricators, Hydrostatic
* Crosby Steam Gage & Valve Co.
* Lunkenheimer Co.

Lubricators (Sight Feed)
* Crosby Steam Gage & Valve Co.

Machine Work
Brown, A. & F. Co.
* Builders Iron Foundry
* Franklin Machine Co.
Johnson, Carlyle Machine Co.
* Jones, W. A. Fdry. & Mch. Co.
Lammert & Mann Co.

Machinery
(Is classified under the headings descriptive of character thereof)

Manometers
Bacharach Industrial Instrument Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Mechanical Draft Apparatus
* American Blower Co.
Clarage Fan Co.
* Green Fuel Economizer Co.

Mechanical Stokers
(See Stokers)

Metal Cutting Machines
(See Cutting-off Machines, Metal)

Metal Equipment
Manufacturing Equipment & Engrg. Co.

Metal Reclaiming Mills
(See Mills, Metal Reclaiming)

Metal Treating
* American Metal Treatment Co.
Rockwell, W. S. Co.

Metals, Bearing
American Crucible Products Co.
* General Electric Co.
Phosphor Bronze Smelting Co.

Metals, Perforated
* Hendrick Mfg. Co.

Metals, Thermostatic
Wilson, H. A. Co.

Meter Provers
Equitable Meter Co.

Meters, Air and Gas
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* Builders Iron Foundry
* General Electric Co.
* Republic Flow Meters Co.

Meters, Boiler Performance
* Bailey Meter Co.

Meters, Condensation
* Simplex Valve & Meter Co.

Meters, Electric
* General Electric Co.
Weston Electrical Instrument Co.

Meters, Feed Water
* Bailey Meter Co.
* Builders Iron Foundry
* General Electric Co.
* H.S.B.W.-Cochrane Corp'n
* Precision Instrument Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Machinery Corp'n

Meters, Flow
Bacharach Industrial Instrument Co.
* Bailey Meter Co.
* General Electric Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.
* Spray Engineering Co.

Meters, Gas
Equitable Meter Co.

Meters, Oil
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)
* General Electric Co.
* H.S.B.W.-Cochrane Corp'n
* Simplex Valve & Meter Co.
* Worthington Pump & Machinery Corp'n

Meters, Pitot Tube
* American Blower Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Meters, Steam
* Bailey Meter Co.
* Builders Iron Foundry

*Catalogue data of firms marked * appear in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1922 Volume*

TEXACO LUBRICANTS FOR ELEVATORS

A SUGGESTIVE LIST

giving recommendations for various parts of most commonly used types of elevators

HYDRAULIC ELEVATORS

Plunger or Piston Rods — Texaco Crater Compound No. 1

Pumping Systems:

Steam Cylinders: Texaco Draco Cylinder Oil or Texaco Pinnacle Cylinder Oil
External Lubrication: Texaco Aleph Oil or Texaco Altair Oil

Emulsifying Compound for water in the System: Texaco Soluble Oil
Sheave Bearings: Texaco Aleph Oil or Texaco Altair Oil

Control Operating Mechanism:

Gear Teeth, etc.: Texaco Thuban Compound
Other Operating Parts: Texaco Aleph Oil or Texaco Altair Oil

Guides:

For Grease Cup Service: Texaco No. 1 Cup Grease
For Hand Application: Texaco Thuban Compound

ELECTRIC ELEVATORS

Gearless Traction Machines:

Motor and Sheave Bearings:

For Chain Oiling Systems: Texaco Aleph Oil
For Roller Bearings: Texaco Petrolatum

Geared Traction Machines:

Motor and Sheave Bearings: Same as above
Worm Gears: Texaco Thuban Compound—Compound B
For Grease Cup Seal and Lubrication of Worm Shaft: Texaco No. 2 Cup Grease
Driving Sheave: Bearing lubrication in special cases, if ordinary gear lubricant is unsuitable, use Texaco Altair Oil or Texaco Ursa Oil.

Guides:

For Cup Grease Service: Texaco Cup Grease No. 1
For Hand Application: Texaco Thuban Compound

Safety Devices: Texaco Aleph Oil

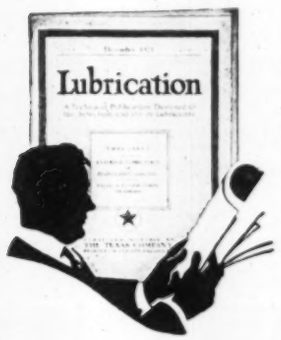
WIRE ROPE LUBRICATION

Texaco Crater Compound No. 2 for ordinary conditions.
Texaco Crater Compound No. 5 where a very heavy lubricant is recommended.

NOTE: If the grade of oil to use for any specific part or machine is not covered in the above list, kindly call on us and we shall be glad to tell you the right oil to use.

If your elevator is operating under unusual conditions which require individual treatment, let us know the name of the manufacturer, the type of machine, the general operating conditions, and we shall be glad to advise you as to the right Texaco Lubricant which will give you the best possible service.

This Page is reprinted from "Lubrication." It accompanies an excellent article on Lubrication of Elevators, which will interest all engineers who are in charge of equipment of this type.



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12-22

* General Electric Co.
* Republic Flow Meters Co.

Meters, V-Notch
* Bailey Meter Co.
* General Electric Co.
* H.S.B.W.-Cochrane Corp'n

Meters, Venturi
* Builders Iron Foundry
* National Meter Co.
* Republic Flow Meters Co.
* Simplex Valve & Meter Co.

Meters, Water
* General Electric Co.
* H.S.B.W. Cochrane Corp'n
* National Meter Co.
* Simplex Valve & Meter Co.
* Worthington Pump & Machinery Corp'n

Milling Machines, Hand
* Whitney Mfg. Co.

Milling Machines, Keyseat
* Whitney Mfg. Co.

Milling Machines, Plain
* Warner & Swasey Co.

Mills, Ball
* Allis-Chalmers Mfg. Co.
* Smidth, F. L. & Co.
* Worthington Pump & Machinery Corp'n

Mills, Blooming and Slabbing
Mackintosh-Hemphill Co.

Mills, Grinding
* Smidth, F. L. & Co.

Mills, Sheet and Plate
Mackintosh-Hemphill Co.

Mills, Structural, Rail and Bar
Mackintosh-Hemphill Co.

Mills, Tube
* Allis-Chalmers Mfg. Co.
* Smidth, F. L. & Co.
* Worthington Pump & Machinery Corp'n

Mining Machinery
* Allis-Chalmers Mfg. Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Worthington Pump & Machinery Corp'n

Monel Metal
Driver-Harris Co.

Monorail Systems
(See Tramrail Systems, Overhead)

Motor-Generators
* Allis-Chalmers Mfg. Co.
* General Electric Co.
* Ridgway Dynamo & Engine Co

Motors, Electric
* Engberg's Electric & Mech. Wks.
* General Electric Co.
* Shepard Electric Crane & Hoist Co.

Motors, Synchronous
* Ridgway Dynamo & Engine Co.

Nickel, Sheet
Driver-Harris Co.

Nipple Threading Machines
* Landis Machine Co. (Inc.)

Nitrogen Gas
Linde Air Products Co.

Non-Return Valves
(See Valves, Non-Return)

Nozzles, Aerating
* Spray Engineering Co.

Nozzles, Blast
* Schutte & Koerting Co.

Nozzles, Sand and Air
* Lunkenheimer Co.

Nozzles, Spray
* Badger, E. B. & Sons Co.
* Cooling Tower Co. (Inc.)
* Schutte & Koerting Co.
* Spray Engineering Co.

Nuts, Machine Screw (Steel & Brass)
* Reed & Prince Mfg. Co.

Odometers
Veeder Mfg. Co.

Ohmeters
* General Electric Co.
Weston Electrical Instrument Co.

Oil and Grease Cups
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)
* Crane Co.
* Lunkenheimer Co.

Oil and Grease Guns
* Royersford Foundry & Machine Co

Oil Burners, Engines, Filters, Pumps, Separators, etc.
(See Burners, Engines, Filters, Pumps, Separators, etc., Oil)

Oil Burning Equipment
* Best, W. N. Furnace & Burner Corp'n
Rockwell, W. S. Co.
* Schutte & Koerting Co.

Oil Filtering and Circulating Systems
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)

Oil Mill Machinery
* Worthington Pump & Machinery Corp'n

Oil Refinery Equipment
* Vogt, Henry Machine Co.

Oil Storage and Distributing Systems
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)

Oil Tanks
* Scaife, Wm. B. & Sons Co.

Oil Well Machinery
* Brownell Co.
* Ingersoll-Rand Co.
* Titusville Iron Works Co.
* Worthington Pump & Machinery Corp'n

Oilers, Sight Feed
* Lunkenheimer Co.

Oiling Devices
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)
* Lunkenheimer Co.

Oiling Systems
* Bowser, S. F. & Co. (Inc.) (Richardson-Phenix Division)
* Lunkenheimer Co.

Oils, Fuel
Texas Co.
* Tide Water Oil Sales Corp'n

Oils, Lubricating
Texas Co.
* Tide Water Oil Sales Corp'n
Vacuum Oil Co.

Ore Handling Machinery
* Brown Hoisting Machinery Co.

Overhead Track System
(See Tramrail Systems, Overhead)

Oxy-Acetylene Supplies
Linde Air Products Co.

Oxygen Gas
Linde air Products Co.

Packing, Ammonia
France Packing Co.

Packing, Asbestos
* Johns-Manville (Inc.)

Packing, Hydraulic
France Packing Co.
* Johns-Manville (Inc.)

Packing, Metallic
France Packing Co.
* Goetze Gasket & Packing Co.
* Johns-Manville (Inc.)

Packing, Rod (Piston and Valve)
France Packing Co.
* Jenkins Bros.
* Johns-Manville (Inc.)

Packing, Rubber
* Jenkins Bros.
* Johns-Manville (Inc.)

Packing, Sheet
* Goetze Gasket & Packing Co.
* Jenkins Bros.
* Johns-Manville (Inc.)

Paint "Diffuselite," Light Reflecting
Wilson, J. G. Corp'n

Paint, Metal
* General Electric Co.
* Johns-Manville (Inc.)

Paper, Drawing
Dietzgen, Eugene Co.
Keuffel & Esser Co.

Paper Sensitized
Dietzgen, Eugene Co.
Keuffel & Esser Co.

Paraffine Wax Plant Equipment
* Vogt, Henry Machine Co.

Partitions, Metal
Wilson, J. G. Corp'n

Partitions, Steel or Wood, Rolling or Folding
Wilson, J. G. Corp'n

Pasteurizers
* Vilter Mfg. Co.

Pencils, Drawing
American Lead Pencil Co.
Dietzgen, Eugene Co.
Dixon, Joseph Crucible Co.
Keuffel & Esser Co.

Penstocks
Smith, S. Morgan Co.

Perforated Metals
(See Metals, Perforated)

Petroleum Products
Texas Co.
* Tide Water Oil Sales Corp'n

Pile Drivers
Clyde Iron Works Sales Co.
Lidgerwood Mfg. Co.

Pinions, Rolling Mill
Mackintosh-Hemphill Co.

Pinions, Steel
* General Electric Co.

Pipe, Cast Iron
* Builders Iron Foundry
* Central Foundry Co.
* United States Cast Iron Pipe & Fdry. Co.
Weatherly Foundry & Mfg. Co.

Pipe, Riveted
* American Spiral Pipe Wks.
* Titusville Iron Works Co.
* Walsh & Weidner Boiler Co.

Pipe, Riveted Steel
* Springfield Boiler Co.

Pipe, Soil
* Central Foundry Co.

Pipe, Steel
* Crane Co.

Pipe Welded
* American Spiral Pipe Wks.
* Crane Co.

Pipe, Wrought Iron
* Crane Co.

Pipe Bending Machines
* Hydraulic Press Mfg. Co.

Pipe Coils, Covering, Fittings, etc.
(See Coils, Covering, Fittings, etc., Pipe)

Pipe Cutting-off Machines
Curtis & Curtis Co.

Pipe Cutting and Threading Machines
* Crane Co.
Curtis & Curtis Co.
* Landis Machine Co. (Inc.)

Pipe Joint Clamps
(See Clamps, Pipe Joint)

Piping, Ammonia
* Frick Co. (Inc.)

Piping, Power
* Crane Co.
* Vogt, Henry Machine Co.

Pitot Tubes
(See Tubes, Pitot)

Planimeters
* American Steam Gauge & Valve Mfg Co.
* Bristol Co.
* Crosby Steam Gage & Valve Co.
Dietzgen, Eugene Co.

Plate Metal Work
(See Steel Plate Construction)

Platinum
Wilson, H. A. Co

Pneumatic Tools, Tubes, etc.
(See Tools, Tubes, etc., Pneumatic)

Pointers, Bolt
* Landis Machine Co. (Inc.)

Polishing Machinery
* Builders Iron Foundry
* Royersford Foundry & Machine Co.

Poppet Valve Engines
(See Engines, Steam, Poppet Valve)

Powdered Fuel Equipment (for Boiler and Metallurgical Furnaces)
* Allis-Chalmers Mfg. Co.
* Combustion Engineering Corp'n
* Quigley Furnace Specialties Co.
* Smidth, F. L. & Co.
* Worthington Pump & Machinery Corp'n

Power Transmission Machinery
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
Eastern Machinery Co.
* Falls Clutch & Machinery Co.
* Franklin Machine Co.
* General Electric Co.
* Jones, W. A. Fdry. & Mch. Co.
* Medart Co.
* Morse Chain Co.
Pryibil, P. Machine Co.
* Royersford Foundry & Machine Co.
* Smidth, F. L. & Co.
Smith, S. Morgan Co.
* Woods T. B. Sons Co.

Presses, Baling
* Franklin Machine Co.
* Hydraulic Press Mfg. Co.
Philadelphia Drying Machinery Co.

Presses, Blanking
* Bliss, E. W. Co.
* Hydraulic Press Mfg. Co.

Presses, Draw
* Bliss, E. W. Co.
* Hydraulic Press Mfg. Co.

Presses, Embossing
* Hydraulic Press Mfg. Co.

Presses, Extruding
* Bliss, E. W. Co.
* Hydraulic Press Mfg. Co.

Presses, Foot
* Bliss, E. W. Co.
* Royersford Foundry & Machine Co.

Presses, Forging
* Bliss, E. W. Co.
* Hydraulic Press Mfg. Co.

Presses, Forming
* Hydraulic Press Mfg. Co.

Presses, Hydraulic
* Falls Clutch & Machinery Co.
* Hydraulic Press Mfg. Co.
Mackintosh-Hemphill Co.
Philadelphia Drying Machinery Co.

Presses, Punching and Trimming
* Bliss, E. W. Co.
Long & Allstatter Co.
* Royersford Foundry & Machine Co.

Presses, Sheet Metal Working
* Bliss, E. W. Co.

Presses, Wax
* Vogt, Henry Machine Co.

Pressure Gages, Regulators, etc.
(See Gages, Regulators, etc., Pressure)

Producers, Gas
* De La Vergne Machine Co.
Otto Engine Works
* Worthington Pump & Machy Corp'n

Propellers
* Morris Machine Works

Pulleys, Friction Clutch
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
Eastern Machinery Co.
* Falls Clutch & Machinery Co.
Johnson, Carlyle Machine Co.
* Jones, W. A. Fdry. & Machine Co.
* Medart Co.
Wood's, T. B. & Sons Co.

Pulleys, Iron
Brown, A. & F. Co.
* Falls Clutch & Machinery Co.
* Gifford-Wood Co.
* Jones, W. A. Fdry. & Mch. Co.
* Medart Co.
* Wood's, T. B. Sons Co.

Pulleys, Paper
Rockwood Mfg. Co.

Pulleys, Steel
* Medart Co.

Pulleys, Wood
* Medart Co.

Pulling Tables (For Annealing Furnaces)
Kenworthy, Chas. F. (Inc.)

Pulverized Fuel Feeders
(See Feeders, Pulverized Fuel)

Pulverizers
Brown, A. & F. Co.
* Smidth, F. L. & Co.

Pump Governors, Valves, etc.
(See Governors, Valves, etc., Pump)

Pumping Engines
(See Engines, Pumping)

Pumping Systems, Air Lift
* Ingersoll-Rand Co.

Pumps, Acid
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Ingersoll-Rand Co.
* Titusville Iron Works Co.

Pumps, Air
* Goulds Mfg. Co.
* Ingersoll-Rand Co.
* Wheeler, C. H. Mfg. Co.

Pumps, Ammonia
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Ingersoll-Rand Co.
* Vogt, Henry Machine Co.
* Worthington Pump & Machinery Corp'n

Pumps, Boiler Feed
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* De Laval Steam Turbine Co.
* Goulds Mfg. Co.
* Ingersoll Rand Co.
* Kerr Turbine Co.
Midwest Engine Corp'n
* Wheeler, C. H. Mfg. Co.
* Worthington Pump & Machinery Corp'n

Pumps, Centrifugal
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.

They will resist corrosion IF— you specify Brass and Bronze

Today, right in your own plant, there are no doubt pieces of apparatus—old veterans—that are Brass or Bronze fitted, because, when you bought them, you demanded them that way.

During the war, unfortunately, you had to take what you could get.

But now you can have all the Brass or Bronze you want. So why not insist on your former practice? Why not save money again by spending a little more in the first place and have machinery that works better, lasts longer and costs less for repairs? The money you will save on repair bills alone will go a long way toward buying your next new machine.

From boiler feeder to condenser, there is not a piece of apparatus that does not need protection from corrosion. Brass and Bronze will give it, and add years of efficiency.

COPPER & BRASS RESEARCH ASSOCIATION

25 Broadway ~ New York

* Cramp, Wm. & Sons Ship & Engine Bldg. Co.
* De Laval Steam Turbine Co.
* Goulds Mfg. Co.
* Ingersoll-Rand Co.
* Kerr Turbine Co.
Lammert & Mann Co.
Midwest Engine Corp'n.
* Morris Machine Works.
Taber Pump Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engineering Co.
* Worthington Pump & Machinery Corp'n

Pumps, Condensation
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Wheeler, C. H. Mfg. Co.

Pumps, Deep Well
* Allis-Chalmers Mfg. Co.
* Davidson, M. T. Co.
* Goulds Mfg. Co.
* Ingersoll-Rand Co
Midwest Engine Corp'n
* Morris Machine Works
* Worthington Pump & Machinery Corp'n

Pumps, Deep Well, Axial
Midwest Engine Corp'n.

Pumps, Dredging
* Ingersoll-Rand Co.
* Morris Machine Works.
* Worthington Pump & Machinery Corp'n

Pumps, Dry Vacuum
(See Pumps, Vacuum)

Pumps, Electric
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
* Goulds Mfg. Co.
* Ingersoll-Rand Co.
* Morris Machine Works
* Worthington Pump & Machinery Corp'n

Pumps, Elevator
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Worthington Pump & Machinery Corp'n

Pumps, Filter Press
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Hydraulic Press Mfg. Co.

Pumps, Hand
* Goulds Mfg. Co.

Pumps, Hydraulic Pressure
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Goulds Mfg. Co.
* Hydraulic Press Mfg. Co
* Ingersoll-Rand Co.
* Morris Machine Works
* Worthington Pump & Machinery Corp'n

Pumps, Measuring (Gasoline or Oil)
* Bowser, S. F. & Co. (Inc.)
(Richardson-Phenix Division)

Pumps, Oil
* Bowser, S. F. & Co. (Inc.)
(Richardson-Phenix Division)
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Goulds Mfg. Co.
* Ingersoll-Rand Co.
* Lunkenheimer Co.
* Worthington Pump & Machinery Corp'n

Pumps, Oil, Force-Feed
* Bowser, S. F. & Co. (Inc.)
(Richardson-Phenix Division)
* Lunkenheimer Co.

Pumps, Oil (Hand)
* Bowser, S. F. & Co. (Inc.)
(Richardson-Phenix Division)

Pumps, Power
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Goulds Mfg. Co.
* Ingersoll-Rand Co.
Midwest Engine Corp'n
* Wheeler Condenser & Engineering Co.
* Worthington Pump & Machinery Corp'n

Pumps, Rotary
* Goulds Mfg. Co.
Lammert & Mann Co.
Taber Pump Co.

Pumps, Steam
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Ingersoll-Rand Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engineering Co.
* Worthington Pump & Machinery Corp'n

Pumps, Sugar House
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Ingersoll-Rand Co.
* Worthington Pump & Machinery Corp'n

Pumps, Sump
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Goulds Mfg. Co.
* Morris Machine Works
* Smidth, F. L. & Co.

Pumps, Tank
Buffalo Steam Pump Co.
* Davidson, M. T. Co.
* Goulds Mfg. Co.
* Ingersoll-Rand Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engineering Co.
* Worthington Pump & Machinery Corp'n

Pumps, Turbine
* Allis-Chalmers Mfg. Co.
Buffalo Steam Pump Co.
* De Laval Steam Turbine Co.
* General Electric Co.
* Ingersoll-Rand Co.
* Kerr Turbine Co.
* Morris Machine Works.
* Worthington Pump & Machinery Corp'n

Pumps, Vacuum
Buffalo Steam Pump Co.
* Davdison, M. T. Co.
* Goulds Mfg. Co.
* Ingersoll-Rand Co.
Lammert & Mann Co.
* Wheeler, C. H. Mfg. Co.
* Wheeler Condenser & Engineering Co.
* Worthington Pump & Machinery Corp'n

Punches, Metal (Hand Power)
* Parker Supply Co.

Punches, Multiple
* Bliss, E. W. Co.
Long & Allstatter Co.
Mackintosh-Hemphill Co.

Punches, Power
* Bliss, E. W. Co.
* Royersford Fdry. & Mch. Co.

Punches and Dies
* Bliss, E. W. Co.
* Royersford Fdry. & Mch. Co.

Punching and Coping Machines
Long & Allstatter Co.

Punching and Shearing Machines
* Bliss, E. W. Co.
Long & Allstatter Co.
* Royersford Fdry. & Mch. Co.

Purifiers, Ammonia
* Frick Co. (Inc.)

Purifiers, Oil
* Bowser, S. F. & Co. (Inc.)
(Richardson-Phenix Division)
Elliott Co

Purifying and Softening Systems, Water
International Filter Co.
* Scaife, Wm. B. & Sons Co.

Pyrometers, Electric
* Bristol Co.
* Crosby Steam Gage & Valve Co.
* Schaeffer & Budenberg Mfg. Co.
* Superheater Co
Taylor Instrument Cos.

Pyrometers, Optical
Taylor Instrument Cos.

Pyrometers, Pneumatic
* Uehling Instrument Co

Pyrometers, Radiation
Taylor Instrument Cos.

Racks, Machine, Cut
* Brownell Co.
* James, D. O. Mfg. Co.
* Jones, W. A. Fdy. & Mch. Co.

Racks, Storage, Metal
Manufacturing Equipment & Engrg. Co.

Radiators, Steam and Water
* American Radiator Co.
* Smith, H. B. Co.

Rams, Hydraulic
* Goulds Mfg. Co.
* Worthington Pump & Machinery Corp'n

Receivers, Air
* Brownell Co.
* Ingersoll-Rand Co.
* Scaife, Wm. B. & Sons Co.
* Walsh & Weidner Boiler Co.
* Wheeler Condenser & Engineering Co.
* Worthington Pump & Machinery Corp'n

Receivers, Ammonia
* Frick Co. (Inc.)

Recording Instruments
(See Instruments, Recording)

Reducing Motions
* Crosby Steam Gage & Valve Co.

Refractories
* King Refractories Co. (Inc.)

Refrigerating Machinery
* De La Vergne Machine Co.
* Frick Co. (Inc.)
* Ingersoll-Rand Co.
* Johns-Manville (Inc.)
Norwalk Iron Works Co.
* Vilter Mfg. Co.
* Vogt, Henry Machine Co.

Refuse Destructors
(See Destructors, Refuse)

Regulators, Blower
* Davis, G. M. Regulator Co.

Regulators, Damper
* Davis, G. M. Regulator Co.
* Kieley & Mueller (Inc.)
* Parker Supply Co.

Regulators, Electric
* General Electric Co.

Regulators, Feed Water
Elliott Co.
* Kieley & Mueller (Inc.)

Regulators, Flow (Steam)
* Davis, G. M. Regulator Co.
* Schutte & Koerting Co.

Regulators, Pressure
* Davis, G. M. Regulator Co.
Equitable Meter Co.
* General Electric Co.
* Illinois Engineering Co.
* Kieley & Mueller (Inc.)
Taylor Instrument Cos.

Regulators, Pump
(See Governors, Pump)

Regulators, Temperature
* Bristol Co.
* Kieley & Mueller (Inc.)
* Powers Regulator Co.
* Sarco Co. (Inc.)
Taylor Instrument Cos.
Wilson, H. A. Co.

Reservoirs, Aerating
* Spray Engineering Co

Resistance Material (Electrical)
Driver-Harris Co.

Revolution Counters
(See Counters, Revolution)

Rivet Heaters, Electric
* General Electric Co.

Riveters, Hydraulic
Mackintosh-Hemphill Co

Riveters, Pneumatic
* Ingersoll-Rand Co.

Riveting Machines
Long & Allstatter Co.

Rivets (Steel, Brass & Copper)
* Reed & Prince Mfg. Co.

Rods, Bronze
Phosphor Bronze Smelting Co.

Roller Bearings
(See Bearings, Roller)

Rolling Doors and Shutters
(See Doors and Shutters, Steel or Wood, Rolling)

Rolling Mill Machinery
Mackintosh-Hemphill Co.

Rolls, Crushing
* Worthington Pump & Machinery Corp'n

Rolls, Steel
Mackintosh-Hemphill Co.

Roofing
* Johns-Manville (Inc.)
Texas Co.

Roofing, Asbestos
* Johns-Manville (Inc.)

Rope, Bronze
Phosphor Bronze Smelting Co.

Rope, Hoisting
Clyde Iron Works Sales Co.
Phosphor Bronze Smelting Co.
* Roebling's, John A. Sons Co.

Rope, Transmission
Phosphor Bronze Smelting Co.
* Roebling's, John A. Sons Co.

Rope, Wire
Clyde Iron Works Sales Co.
* Roebling's, John A. Sons Co.

Rope Drives
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
* Falls Clutch & Machinery Co.
* Medart Co.
* Wood's, T. B. Sons Co.

Rubber Goods, Mechanical
* Jenkins Bros.

Sand Blast Apparatus
* De La Vergne Machine Co.

Saw Mill Machinery
* Allis-Chalmers Mfg. Co.

Saw Mills, Portable
* Frick Co. (Inc.)

Scales, Fluid Pressure
* Crosby Steam Gage & Valve Co.

Screens, Perforated Metal
* Hendrick Mfg. Co.

Screens, Revolving
* Allis-Chalmers Mfg. Co
* Gifford-Wood Co.
* Hendrick Mfg. Co.
* Smidth, F. L. & Co.

Screens, Shaking
* Allis-Chalmers Mfg. Co.
* Gifford-Wood Co.
* Hendrick Mfg. Co.

Screw Cutting Dies
(See Dies, Thread Cutting)

Screws, Drive (Hardened)
* Parker Supply Co.

Screw Machines, Hand
* Jones & Lamson Mch. Co.
* Warner & Swasey Co.

Screws, Cap
* Scovill Mfg. Co.

Screws, Cap & Set
Allen Mfg. Co.
* Reed & Prince Mfg. Co.

Screws, Cap & Set (Steel)
* Reed & Prince Mfg. Co.

Screws, Machine (Steel and Brass)
* Reed & Prince Mfg. Co.

Screws, Safety Set
Allen Mfg. Co.
* Bristol Co.

Screws, Self-Tapping (Hardened)
* Parker Supply Co.

Screws, Wood (Steel, Brass and Bronze)
* Reed & Prince Mfg. Co.

Separators, Ammonia
* De La Vergne Machine Co.
Elliott Co.
* Frick Co. (Inc.)
Milwaukee Steam Appliance Co.
* Vogt, Henry Machine Co.

Separators, Oil
* Crane Co.
* De La Vergne Machine Co.
Elliott Co.
* H.S.B.W.-Cochrane Corp'n
* Illinois Engineering Co.
* Kieley & Mueller (Inc.)
Milwaukee Steam Appliance Co.
* Vogt, Henry Machine Co.

Separators, Steam
* Crane Co.
Elliott Co.
* H.S.B.W.-Cochrane Corp'n
* Illinois Engineering Co.
* Kieley & Mueller (Inc.)
Milwaukee Steam Appliance Co.
* Vogt, Henry Machine Co.

Shafting
* Allis-Chalmers Mfg. Co.
Brown, A. & F. Co.
Cumberland Steel Co.
* Falls Clutch & Mchy. Co.
* Medart Co.
* Union Drawn Steel Co.
* Wood's, T. B. Sons Co.

Shafting, Bronze
Phosphor Bronze Smelting Co

Shafting, Cold Drawn
* Medart Co.

Shafting, Flexible
* Gwilliam Co.

Shapes, Cold Drawn Steel
* Union Drawn Steel Co.

Sharpening Devices, Rock Drill
* Ingersoll-Rand Co.

Shears, Alligator
Long & Allstatter Co.
* Royersford Foundry & Machine Co.

Twenty Thousand Engineers from many industries, who specify or otherwise influence the selection of mechanical equipment

will be present in person, or spirit at the forthcoming Annual Meeting of

The American Society of Mechanical Engineers

Time and Place

The 1922 A.S.M.E. Annual Meeting will be held as usual at the Engineering Societies Building, New York City, from December 4th to December 7th inclusive.

Program

This Meeting will be notable for five Joint Sessions which are to be held respectively with the American Economic Association, The American Society of Refrigerating Engineers, The American Society of Safety Engineers, The American Engineering Standards Committee and the Stoker Manufacturers Association.

An outstanding feature will be the general session of Wednesday evening, December 6th, at which E. M. Herr, President of the Westinghouse Electric & Manufacturing Co., will talk on "The Human Problem in Industry" and Dr. Wesley C. Mitchell, Director of the National Bureau of Economic Research, will speak on the subject of "Making Money and Making Goods."

Important professional sessions will be held on Management, Materials Handling, Machine Shop Methods, Railroads, Power Plants, Forest Products, Ordnance, Aeronautics, Refrigeration, Fuels, Safety Engineering, Training for the Industries, etc., at each of which addresses will be made by engineers of distinction and special experience along lines indicated by the titles of their respective papers.

A.S.M.E. Annual Meeting Report

A complete and accurate report of this meeting will naturally be of great interest to the 17,000 members of the Society, as well as to those other thousands of engineers and industrial executives who have registered their interest in its constructive activities by subscribing for its monthly journal, *Mechanical Engineering*.

A.S.M.E. Annual Meeting Number

Mechanical Engineering for January, 1923, will contain a full report of the entire meeting; and will be read with keen appreciation by all who attend, as well as by those whose business affairs prevent their attendance, and who are thereby compelled to depend upon it for an authoritative account of the many important facts that will be brought out.

Each month *Mechanical Engineering* contains the advertising of leading manufacturers in practically all divisions of mechanical equipment. Many of these advertisers increase their space for the January issue; while many other manufacturers who do not use space regularly recognize the extra importance of this number, and arrange for special representation therein. Both in point of editorial interest, and in the volume of advertising carried, it is always the most noteworthy issue of the year.

Circulation

The constantly growing circulation of *Mechanical Engineering* now exceeds 21,500 a month, while additional demands for the January number will require us to print a total of at least 22,000 copies. This circulation represents in one grouping the largest number of prominent engineers identified with the selection and purchase of mechanical equipment ever recorded as readers of a monthly engineering publication.

We Can Help Prepare Your Advertisement

Our Copy Service Department is composed of men who combine advertising experience with an accurate knowledge of engineering matters, and they will be glad to coöperate in preparing copy which will insure a satisfactory representation for your firm. Upon request, a complete advertising suggestion will be submitted for your consideration.

What Space Costs

Rates for single insertions of new advertisers in the January issue are as follow:

Full page	$115.00
Half page	62.00
Quarter page	33.00

(Annual rates on application)

Adequate listings of products in the Classified Index are included if order is received in time to permit of the necessary rearrangements of the Index.

Closing Date—December 4, 1922

Because of the increased size of both editorial and advertising sections in the January number we cannot promise to submit proof on any copy received after December 4. Earlier copy will naturally secure more careful attention than that received at the last minute. Please make your reservation promptly and let us have copy and cuts as soon as possible thereafter.

MECHANICAL ENGINEERING

29 West 39th Street New York

Shears, Hydraulic
Mackintosh-Hemphill Co.

Shears, Plate
Long & Allstatter Co.
Mackintosh-Hemphill Co.

Shears, Squaring
* Bliss, E. W. Co.

Sheaves, Rope
Brown, A. & F. Co.
Clyde Iron Works Sales Co.
* Falls Clutch & Machinery Co.
* Jones, W. A. Fdry. & Mch. Co.
Mackintosh-Hemphill Co.
* Medart Co.
* Wood's, T. B. Sons Co.

Sheet Metal Work
* Allington & Curtis Mfg. Co.
* Hendrick Mfg. Co.

Sheet Metal Working Machinery
* Bliss, E. W. Co.

Sheets, Brass
* Scovill Mfg. Co.

Sheets, Bronze
* Hendrick Mfg. Co.
Phosphor Bronze Smelting Co.

Shelving, Metal
Manufacturing Equipment & Engrg. Co.

Shutters, Automatic Fire
Wilson, J. G. Corp'n

Shutters, Fireproof
Wilson, J. G. Corp'n

Shutters, Steel or Wood, Rolling
Wilson, J. G. Corp'n

Siphons (Steam-Jet)
* Schutte & Koerting Co.

Sirens
(See Whistles, Steam)

Slide Rules
Dietzgen, Eugene Co.
Gilson Slide Rule Co.
Keuffel & Esser Co.

Slitting Machines
* Bliss, E. W. Co.

Sluice Gates
(See Gates, Sluice)

Smoke Recorders
* Sarco Co. (Inc.)

Smoke Stacks and Flues
(See Stacks, Steel)

Sockets, Wire Rope
(See Wire Rope Fastenings)

Soot Blowing Systems
Bayer Co.
Diamond Power Specialty Corp'n

Special Machinery
Brown, A. & F. Co.
* Builders Iron Foundry
* Cramp, Wm & Sons Ship & Engine Bldg. Co.
* Fawcus Machine Co.
* Franklin Machine Co.
Lammert & Mann Co.
Mackintosh-Hemphill Co.
* Smidth, F. L. & Co.
* Vilter Mfg. Co.

Speed Reducing Transmissions
* Cleveland Worm & Gear Co.
* De Laval Steam Turbine Co.
* General Electric Co.
* James, D. O. Mfg. Co.
* Jones, W. A. Fdry. & Mch. Co.

Spray Cooling Systems
* Cooling Tower Co. (Inc.)
* Spray Engineering Co.

Spray Nozzles
(See Nozzles, Spray)

Sprays, Water
* Badger, E. B. & Sons Co.
* Cooling Tower Co. (Inc.)
* Spray Engineering Co.

Springs, Coiled
New York Wire & Spring Co.

Springs, Steel
New York Wire & Spring Co.

Springs, Vanadium
New York Wire & Spring Co.

Springs, Wire
New York Wire & Spring Co.

Sprinklers, Spray
* Cooling Tower Co. (Inc.)
* Spray Engineering Co.

Sprockets
Baldwin Chain & Mfg. Co.
* Gifford-Wood Co.
* Medart Co.

Stacks, Steel
* Bigelow Co.
* Brownell Co.
* Casey-Hedges Co.
* Cole, R. D. Mfg. Co.
Heine Boiler Co.
* Hendrick Mfg. Co.
* Titusville Iron Works Co.
Union Iron Works
* Vogt, Henry Machine Co.
* Walsh & Weidner Boiler Co.

Standpipes
* Cole, R. D. Mfg. Co.
* Walsh & Weidner Boiler Co.

Standpipes, Concrete
Heine Chimney Co.

Steam Engines, Separators, Superheaters, Traps, Turbines, etc.
(See Engines, Separators, Superheaters, Traps, Turbines, etc., Steam)

Steam Specialties
* Crane Co.
* Davis, G. M. Regulator Co.
* Illinois Engineering Co.
* Kieley & Mueller (Inc.)
* Lunkenheimer Co.
Milwaukee Steam Appliance Co.
* Sarco Co. (Inc.)

Steel, Alloy
* Union Drawn Steel Co.

Steel, Bright Finished
* Union Drawn Steel Co.

Steel, Cold Drawn
* Union Drawn Steel Co.

Steel, Cold Rolled
* Union Drawn Steel Co.
Cumberland Steel Co.

Steel, High Speed
Haynes Stellite Co.

Steel, Nickel
* Union Drawn Steel Co.

Steel, Open-Hearth
* Union Drawn Steel Co.

Steel, Rock Drill
* Ingersoll-Rand Co.

Steel, Screw, Cold Drawn
* Union Drawn Steel Co.

Steel, Strip (Cold Rolled)
Driver-Harris Co.

Steel, Tool
Haynes Stellite Co.

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* Hendrick Mfg. Co.
* Keeler, E. Co.
* Titusville Iron Works Co.
Union Iron Works
* Vogt, Henry Machine Co.
* Walsh & Weidner Boiler Co.

Steering Engines
(See Engines, Steering)

Stills
* Vogt, Henry Machine Co.

Stocks and Dies
Curtis & Curtis Co.
* Landis Machine Co. (Inc.)

Stokers, Chain Grate
* Babcock & Wilcox Co.
* Combustion Engineering Corp'n
Green Engineering Co.
* Illinois Stoker Co.

Stokers, Hand Operated
* Gibby Engineering Co.
* McClave Brooks Co.

Stokers, Overfeed
* Detroit Stoker Co.
* Gibby Engineering Co.
* McClave Brooks Co.
* Murphy Iron Works

Stokers, Underfeed
* American Engineering Co.
* Combustion Engineering Corp'n
* Detroit Stoker Co.
* Riley, Sanford Stoker Co.

Stools and Chairs, Metal
Manufacturing Equipment & Engrg. Co.

Strainers, Oil
* Bowser, S. F. & Co. (Inc.)
(Richardson-Phenix Division)

Strainers, Steam
* Kieley & Mueller (Inc.)

Strainers, Water
Elliott Co.
* Kieley & Mueller (Inc.)
* Schutte & Koerting Co.

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* Superheater Co.

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* Power Specialty Co.
* Superheater Co.

Superheaters, Steam (Marine)
* Power Specialty Co.
* Superheater Co.

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* General Electric Co.

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* General Electric Co.

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Weston Electrical Instrument Co.

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(See Converters, Synchronous)

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Keuffel & Esser Co.

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* Bristol Co.
* Schaeffer & Budenberg Mfg. Co.
Veeder Mfg. Co.
Weston Electrical Instrument Co.

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* Schaeffer & Budenberg Mfg. Co.

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(See Blocks, Tackle)

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* Casey-Hedges Co.
* Cole, R. D. Mfg. Co.
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* Hendrick Mfg. Co.
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* Frick Co. (Inc.)

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* Hendrick Mfg. Co.
* Titusville Iron Works Co.
* Vogt, Henry Machine Co.
* Walsh & Weidner Boiler Co.

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Heine Boiler Co.
* Hendrick Mfg. Co.
* Titusville Iron Works Co.
Union Iron Works
* Vogt, Henry Machine Co.
* Walsh & Weidner Boiler Co.

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* Cole, R. D. Mfg. Co.
Green Engineering Co.
* H.S.B.W.-Cochrane Corp'n
* Hendrick Mfg. Co.
Herbert Boiler Co.
* Scaife, Wm. B. & Sons Co.
* Titusville Iron Works Co.
* Vogt, Henry Machine Co.
* Walsh & Weidner Boiler Co.

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* Walsh & Weidner Boiler Co.

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* Scaife, Wm. B. & Sons Co.

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* Whitney Mfg. Co.

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(See Regulators, Temperature)

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* Bailey Meter Co.
Taylor Instrument Cos.

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* General Electric Co.
* Powers Regulator Co.
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(See Regulators, Time)

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Haynes Stellite Co.

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* Best, W. N. Furnace & Burner Corp'n

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Northern Engineering Wks.
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Clyde Iron Works Sales Co.
Lidgerwood Mfg. Co.
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* Allis-Chalmers Mfg. Co.
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(See Power Transmission Machinery)

Transmissions, Automobile
* Foote Bros. Gear & Machine Co.

Traps, Radiator
* American Radiator Co.
* Sarco Co. (Inc.)

Traps, Return
* American Blower Co.
* Crane Co.
* Illinois Engineering Co.
* Kieley & Mueller (Inc.)

Traps, Steam
* American Blower Co.
* American Steam Gauge & Valve Mfg. Co.
* Crane Co.
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Elliott Co.
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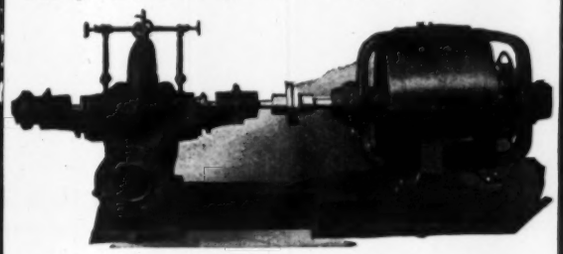

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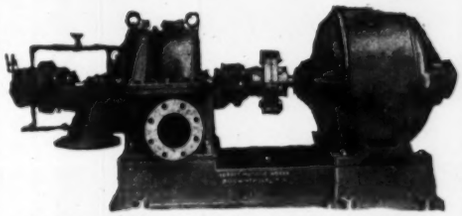

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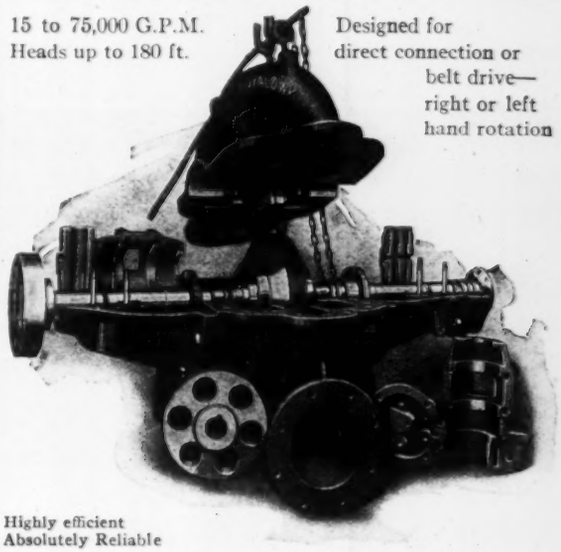

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(See Valves, Non-Return)

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(See Mills, Cinder, Water)

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(See Circulators, Filters, Gages, Heaters, Meters, Strainers, etc., Water)

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(See Boilers, Water Tube)

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(See Turbines, Hydraulic)

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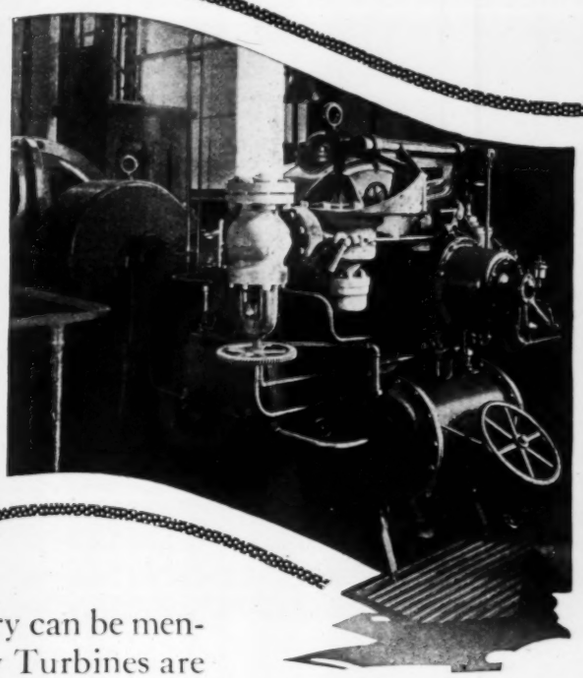

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The fact that the exhaust is free from oil makes the Terry Turbine a superior drive in many installations. Whether that exhaust is to be condensed and made into ice or whether it is to be returned to the boiler, there is a saving which makes this feature an important one to consider when selecting a prime mover. Remember, there is no oil in the exhaust of

T-746

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Offices in Principal Cities in U.S.A. also in Important Industrial Foreign Countries

The Terry Steam Turbine Co.
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*Doehler Die-Casting Co	103
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*Hooven, Owens, Rentschler Co	4
*Hydraulic Press Mfg. Co	61
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*Jones, W. A. Foundry & Machine Co	81
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*Medart Co	76
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*Moore Steam Turbine Corp'n	—
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*Norma Co. of America	88, 100
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*Simplex Valve & Meter Co	71
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*Timken Roller Bearing Co	89
*Titusville Iron Works Co	41
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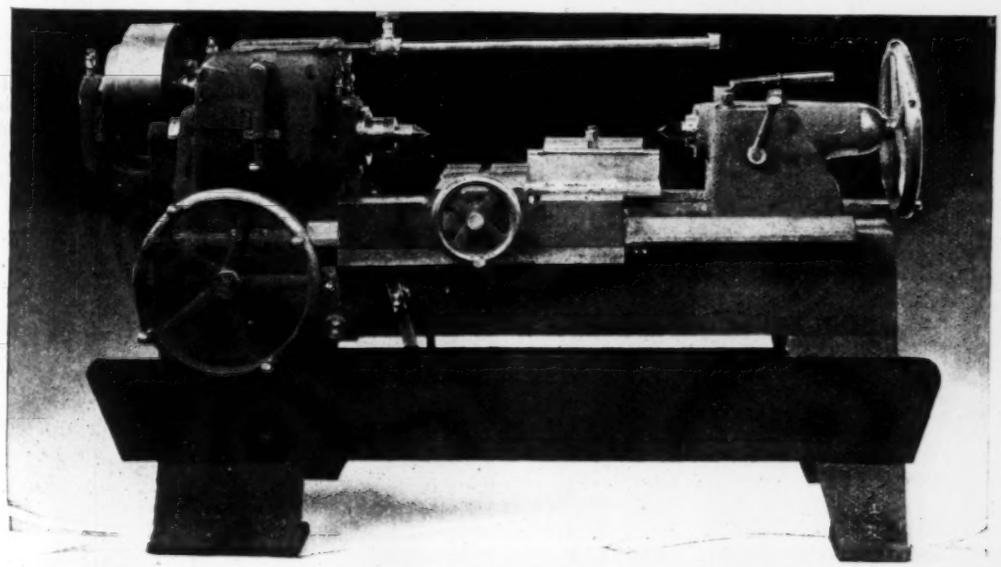
*Catalogue data of firms marked * appear in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1922 Volume*

SKF



Ball Bearings on Lathe Spindles Permit
Greater Speeds and Heavier Cuts and Feeds

WHEN ordinary thrust bearings are used on lathe spindles, the fiber or steel washers act as brakes when the load is applied. This wastes considerable power in destructive wear and reduces the power of the cut.

The power thus wasted may be utilized for producing quicker, cleaner cuts when **SKF** marked thrust ball bearings are used. For this type of bearing provides for transmitting the shocks and strains from the cutting tool to the head stock and frame without appreciable friction and with practically no wear or heating.

The result is a greater and better maintained accuracy and permanent relief from bearing troubles. This has led not only to the wide adoption of thrust ball bearings on lathe spindles but also to the extensive use of radial ball bearings on spindles, gears and other revolving parts as well.

THE SKAYEF BALL BEARING COMPANY
Supervised by **SKF** INDUSTRIES, INC., 165 Broadway, New York City

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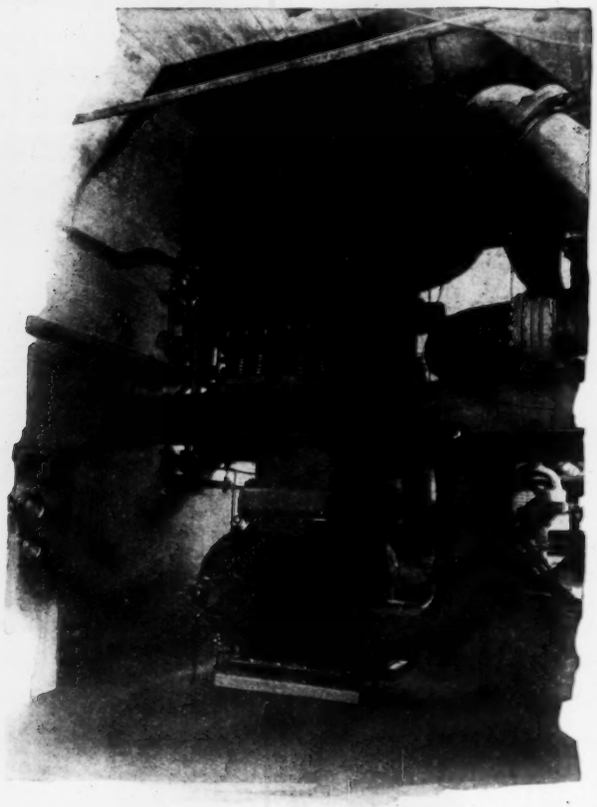
Normal View *Deflected View*

See Our Data on Page 10 in 1922 A.S.M.E. Condensed Catalogues

BALL BEARINGS
The Highest Expression of the Bearing Principle

Elliott-Ehrhart Condensers

At
Pennsylvania Power
and Light Co.,
Harwood Plant



"These are high vacuum days!"

This Elliott-Ehrhart Jet Condenser, serving a 12,500 K.W. General Electric Turbine, represents one of the largest single Jet Condenser installations in the country.

In addition to excellent vacuum producing ability, the Condenser shows unparalleled pump efficiency with minimum requirements of power and ejector steam.

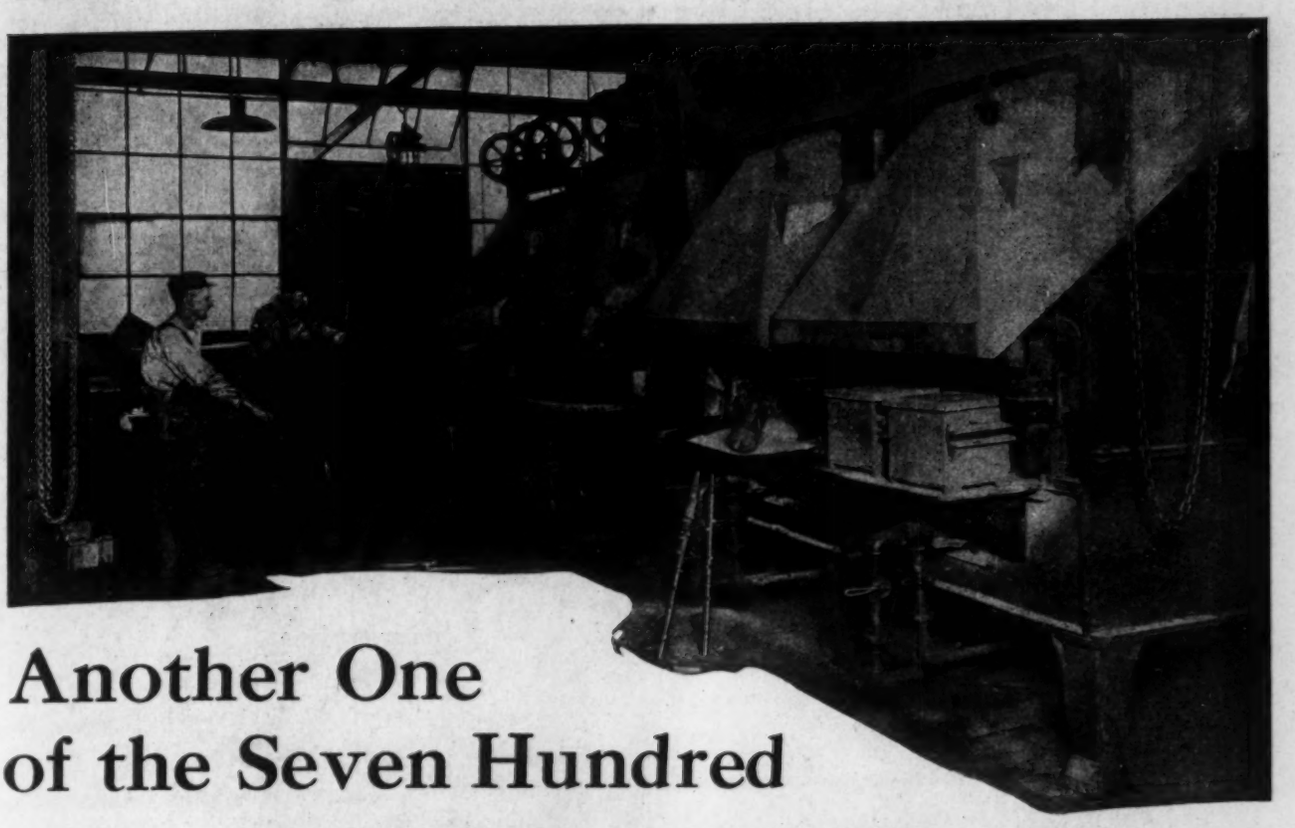
The centrifugal pump when operating against the specified external head has an efficiency of approximately 80%. The ejector steam consumption is but 3000 lbs. per hour.

Such results have heretofore been unknown in connection with centrifugal pumps exhausting from high vacuum. Few, if any, ejectors are as efficient as the ones on this Condenser.

C-248

Condensers
Air Ejectors
Deaerators
Twin Strainers
Twin Filters
Feed Water Heaters
Steam Separators
Receiver Separators
Blow-Off Valves
Steam Traps

ELLIOTT COMPANY
Pittsburgh, Pa.
GENERAL SALES OFFICES: JEANNETTE, PA.
District Sales and Service Offices in Principal Cities



Another One of the Seven Hundred

Seven hundred heat-treating plants equipped with Cast Nichrome Containers, Muffles, Retorts, Pyrometer Protection Tubes, Burning Racks, etc.—because Nichrome stands up under high heat for many thousands of hours of *superior* service.

And that means greater dependability in the heat-treated product—lower operating costs. Nichrome does not absorb carbon and it is practically immune to oxidizing influences. Unchanging in physical characteristics; covers always fit snugly. Luting is unnecessary and the soft spots caused by luting material becoming mixed with compounds, are eliminated. Economy service—quality results: that is the double advantage enjoyed by seven hundred users of Cast Nichrome.

All Nichrome Castings are Manufactured under Patents Dated 1916, 1917, 1918 and owned by

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TRADE MARK REG. U. S. PAT. OFF.

Nichrome

CAST **Heat Treating Containers**

Endure in High Temperatures

Don't forget to visit Booth No. 41 at the POWER SHOW

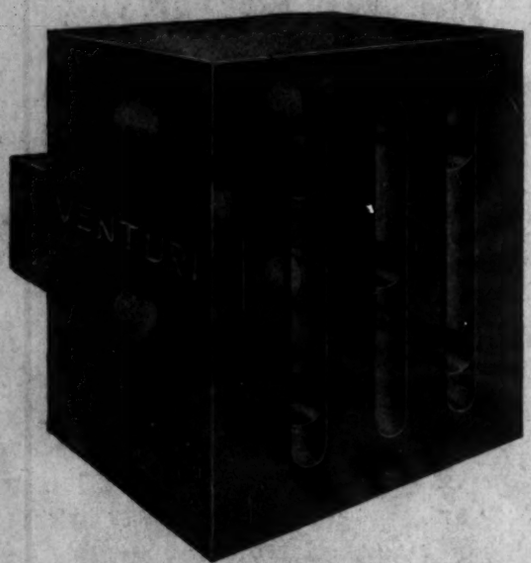
**Grand Central Palace,
New York City,
December 7th to 13th**

and see

The Venturi Nozzle Type

DRAKE BLOCKS

The Standard for Furnace Wall Construction



They Lead in Furnace Block Design

Three Important Points of Construction

Venturi Nozzles	Confined area within nozzles through blocks increases the velocity of air to fuel bed, thereby increasing clinker safety zone. Utilizes the under grate air supply without increasing the pressure.
Fluted Faces	Positively prevent coal and ash from plugging holes and afford 20% cooling area on face of block. Permit jets to drive air in fuel bed.
Lugs	Every block has two lugs so that it is firmly bonded, thus giving strength equal to a solid wall leaving air space that maintains uniform volume and velocity of air at each orifice in blocks.

DRAKE BLOCKS may be applied to Wood Burning, Oil Burning, Pulverized Fuel, Hand Fired and Stoker-Fired Furnaces.

Drake blocks as they are made today are the result of development in design of furnace blocks with air nozzles giving the highest co-efficient of air discharge. High co-efficiency is essential to and aids combustion. It insures a greater clinker safety zone. High co-efficiency gives the maximum of cooling with minimum of static pressure.

Tests have proven the worth of DRAKE BLOCKS in modern engineering practice. Repeat orders prove their merits.

Let us tell you more about DRAKE BLOCKS —Write to us or our nearest branch for details.

DRAKE BLOCKS are manufactured and licensed under the DRAKE and BERNITZ patents—thus affording a double patent protection for our clients.

Drake Non-Clinkering Furnace Block Company, Inc.

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